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Regeneration Outlook on BLM Lands in the Siskiyou Mountains

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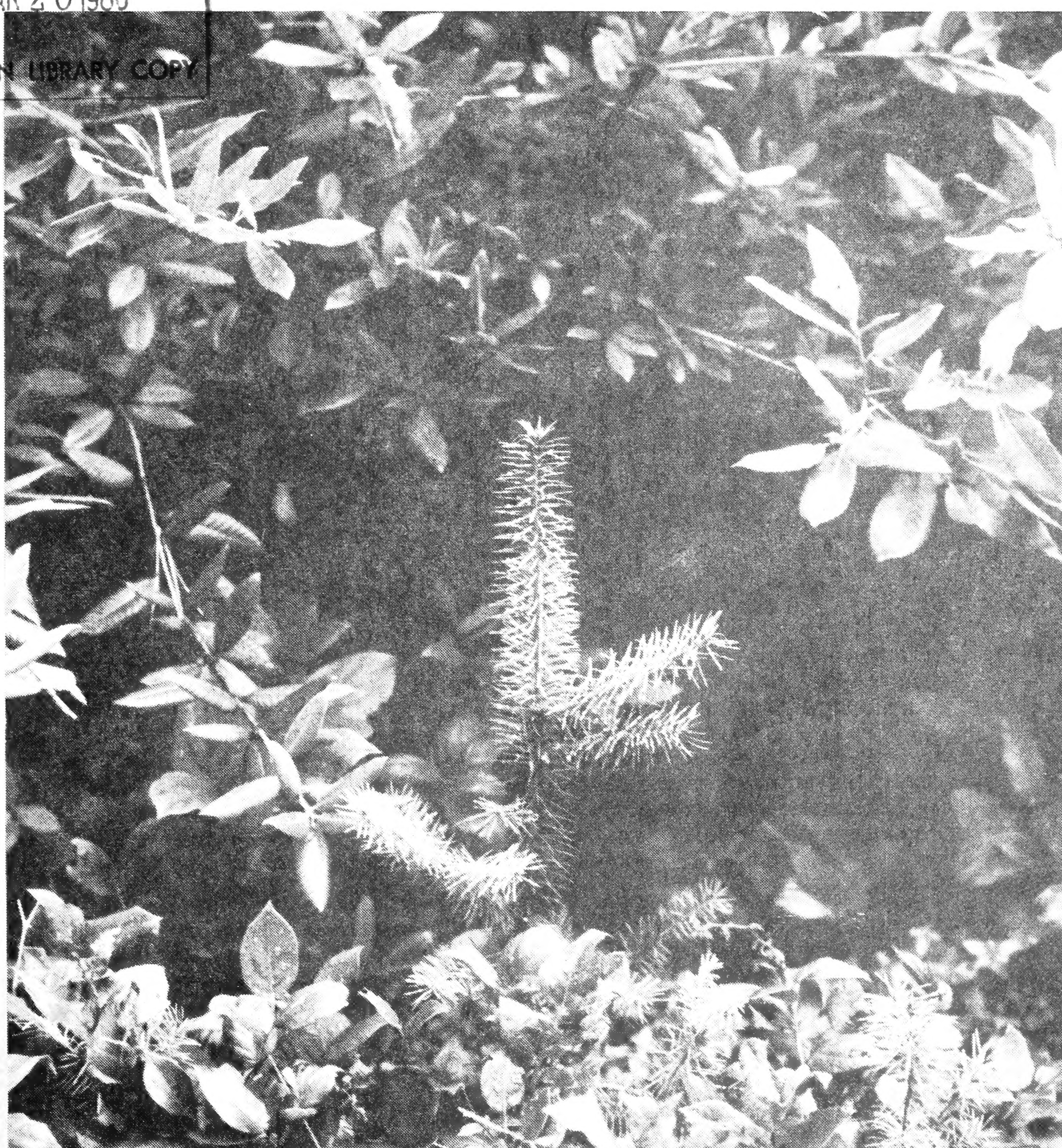

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Abstract

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A survey of timberland cut over from 1956 to 1971 in the Applegate, Evans, and Galice-Glendale areas of southwestern Oregon showed that both partial cuts and clearcuts were well stocked with a combination of regeneration that started before and after harvest cutting. Advance regeneration was a major stocking component in partial cuts. Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) was the predominant species of advance and subsequent regeneration in both partial cuts and clearcuts. Stocking differed significantly by forest type, soil series, soil origin, soil depth, and stream drainage and correlated with an array of environmental variables. Regression equations describe present stocking patterns, and other equations predict future stocking based on variables that can be observed or specified before harvest. Reforestation can be improved by paying greater attention to forest type, soil series, site conditions, and differences in plant communities when selecting harvest method and reforestation techniques.

Keywords: Regeneration (stand), regeneration (natural), regeneration (artificial), clearcutting systems, partial cutting, stand development, Oregon (Siskiyou Mountains), southwestern Oregon.

Summary

For more than a decade, various intensities of partial cutting have been used in the Siskiyou Mountains of southwestern Oregon by the Bureau of Land Management, U.S. Department of the Interior, and by other land managers to foster establishment of natural regeneration. Difficulties experienced in reforesting some clearcuts were a prime reason for the emphasis on partial cutting. This paper encompasses the second half of a comprehensive study undertaken cooperatively to evaluate reforestation results obtained on the Medford District from both clearcutting and partial cutting, to identify influencing variables and problems, and to recommend improvements in silvicultural practices.

Stocking levels, composition of regeneration, and species dominance were determined from data collected on 134 plots randomly located in partial cuts and clearcuts logged from 1956 to 1971 in the Applegate, Evans, and Galice-Glendale areas. Each plot consisted of twenty 4-milacre (0.00162-ha) subplots, located systematically in a 2-acre (0.8-ha) grid. Stocking (occurrence) data were also sorted into environmental groupings and subjected to correlation, regression, and variance analyses to identify significant associations.

Both partial cuts and clearcuts in the Siskiyous were well stocked[1/] with regeneration that started before and after harvest cutting. Total stocking varied somewhat among the Applegate, Evans, and Galice-Glendale areas, but averaged 81 percent in partial cuts and 77 percent in clearcuts. In partial cuts, advance regeneration comprised 40 to 65 percent of the total stocking. Clearcuts had more regeneration that started after harvesting than did partial cuts; clearcuts averaged 71 percent subsequent stocking versus 56 percent for partial cuts.

[1/]Compared to a full stocking of 250 uniformly distributed trees per acre (618 per ha).

Survey results indicated that 94 percent of the acreage partially cut in the Siskiyou part of the Medford District between 1956 and 1971 was stocked at the 50-percent level or higher; nearly half the acreage was at the 90-percent level or higher. About 90 percent of the acreage clearcut between 1956 and 1971 also was stocked at the 50-percent level or higher; 70 percent of the clearcut acreage had a stocking level of 70 percent or higher.

Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) predominated among advance and subsequent regeneration in both partial cuts and clearcuts. Incense-cedar (*Libocedrus decurrens* Torr.), sugar pine (*Pinus lambertiana* Dougl.), and true firs (*Abies* sp.) were commonly present in partial cuts, whereas ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) was the second most common species in clearcuts. Advance regeneration was dominant in over half of the stocked subplots in partial cuts and in about 20 percent of the stocked subplots in clearcuts. Two or more species were present on 51 percent of all stocked 4-milacre (0.00162-ha) subplots.

The Applegate, Evans, and Galice-Glendale areas have such features in common as a substantial range in elevation, a well-dissected terrain, mostly moderate to deep soils, and similar growing seasons and temperature patterns. All three are inland areas that bear some rain shadow effects from adjacent higher ridges and peaks. The Galice-Glendale area is closest to the coast and receives the most precipitation, even though the Applegate cutovers average highest in elevation. Residual overstory in partial cuts averaged about 50 percent canopy. About two-thirds of the soil surface had been disturbed in clearcuts, about half in partial cuts. Woody perennials were the dominant ground cover on 94 percent of the plots sampled.

Average stocking differed significantly by forest type, soil series, soil origin, soil depth, geographical location, and stream drainage. In partial cuts, average stocking was less in the Douglas-fir forest type than in the sugar pine type, but the reverse order prevailed in clearcuts. Stocking tended to be higher than average on soils of granitic origin and lower than average on soils of volcanic origin. Stocking in clearcuts was highest on the deepest soils but did not differ significantly between soils of shallow depth and those of medium depth. Total stocking in both partial cuts and clearcuts averaged highest in the western part of the territory and somewhat lower but variable in ranges farther inland. Partial cuts in small drainages that flow directly into the middle section of the Rogue River had the highest total, advance, and subsequent stocking. Stocking in clearcuts was highest in the west fork of the Cow Creek drainage and lowest in the Applegate River drainage.

Stocking correlated with an array of environmental variables that differed for partial cuts and clearcuts and for the Applegate, Evans, and Galice-Glendale areas. Correlations based on stocking data from individual areas accounted for the most variation, those based on forest types were second, and those based on the geographic areas combined were lowest. In both partial cuts and clearcuts, stocking usually decreased as slope increased; as amount of seedbed covered with logs, wood, and bark increased; and as the cover of woody perennials increased. Higher stocking was generally but not always associated with greater precipitation. Stocking in partial cuts was higher on slopes most exposed to the sun and in clearcuts on slopes least exposed to the sun. Regression equations were calculated that describe present stocking patterns, and other equations predict future stocking based on variables that can be observed or specified before harvest.

Evidence from the sampled cutovers clearly demonstrates that regeneration can be established successfully following either partial cutting or clearcutting. Substantial stocking can often be achieved, particularly in partial cuts, by just saving advance regeneration plus relying on accretion from natural regeneration that starts subsequent to logging. Limited evidence indicates that clearcuts in selected areas could be regenerated by broadcast seeding. The most positive reforestation approach following both clearcutting and partial cutting is to plant promptly and provide the young stand with sufficient protection from animals and enough freedom from competing vegetation for quick development. Certainty of success can be enhanced by paying close attention to local conditions—geographic area, forest type, soil series, aspect, plant community, and seedbed disturbance—when preparing the reforestation prescription, reforesting promptly, and tending the developing stand on a timely basis.

If shelterwood is the chosen silvicultural system, much can be done to achieve maximum effectiveness from its application in nonuniform virgin stands. A thorough preharvest assessment of the site and existing stand must be coupled with flexibility in the amount and timing of overstory removal. The level of harvest should foster survival and growth of advance regeneration as well as the prompt establishment of additional regeneration. Density control of both advance and subsequent regeneration is needed. The foremost issues requiring research include determining where shelterwood is truly needed, how much overstory to leave, and how much competing vegetation can be tolerated.

Contents

Introduction

Conifer forests in southwestern Oregon grow on a diversity of sites and contain a variable mix of species. Common obstacles to the reestablishment of conifers after timber harvest include intense radiation, high temperatures, summer drought, periodic seed crops, and competing vegetation. Success of reforestation is variable, and the locations and conditions where tree establishment is easy or difficult are inadequately identified.

In the early 1960's, the primary method of timber harvest used by the Medford District of the Bureau of Land Management (BLM), U.S. Department of the Interior, shifted from clearcutting to partial cutting. Difficulty experienced in artificially reforesting some clearcuts was a key reason for changing cutting practices. It was believed the environment provided by a partial overstory would permit ready establishment of natural regeneration. But this premise required confirmation.

After sufficient time had elapsed to permit establishment of regeneration, the Pacific Northwest Research Station and the Oregon State Office of BLM jointly undertook an evaluation of reforestation on the Medford District. The study had two primary objectives: (1) to evaluate in depth the results of reforestation efforts and (2) to develop improved silvicultural guidelines for establishing conifer regeneration in southwestern Oregon. Information developed for Dead Indian and Butte Falls, the eastern parts of the Medford District, was published as Research Paper PNW-284, "Regeneration Outlook on BLM Lands in the Southern Oregon Cascades" (Stein 1981). This report summarizes comparable information obtained in 1974-76 field surveys of cutovers located in three geographic areas called, for convenience, Applegate, Evans, and Galice-Glendale; these are the western or Siskiyou Mountain parts of the Medford District (fig. 1).

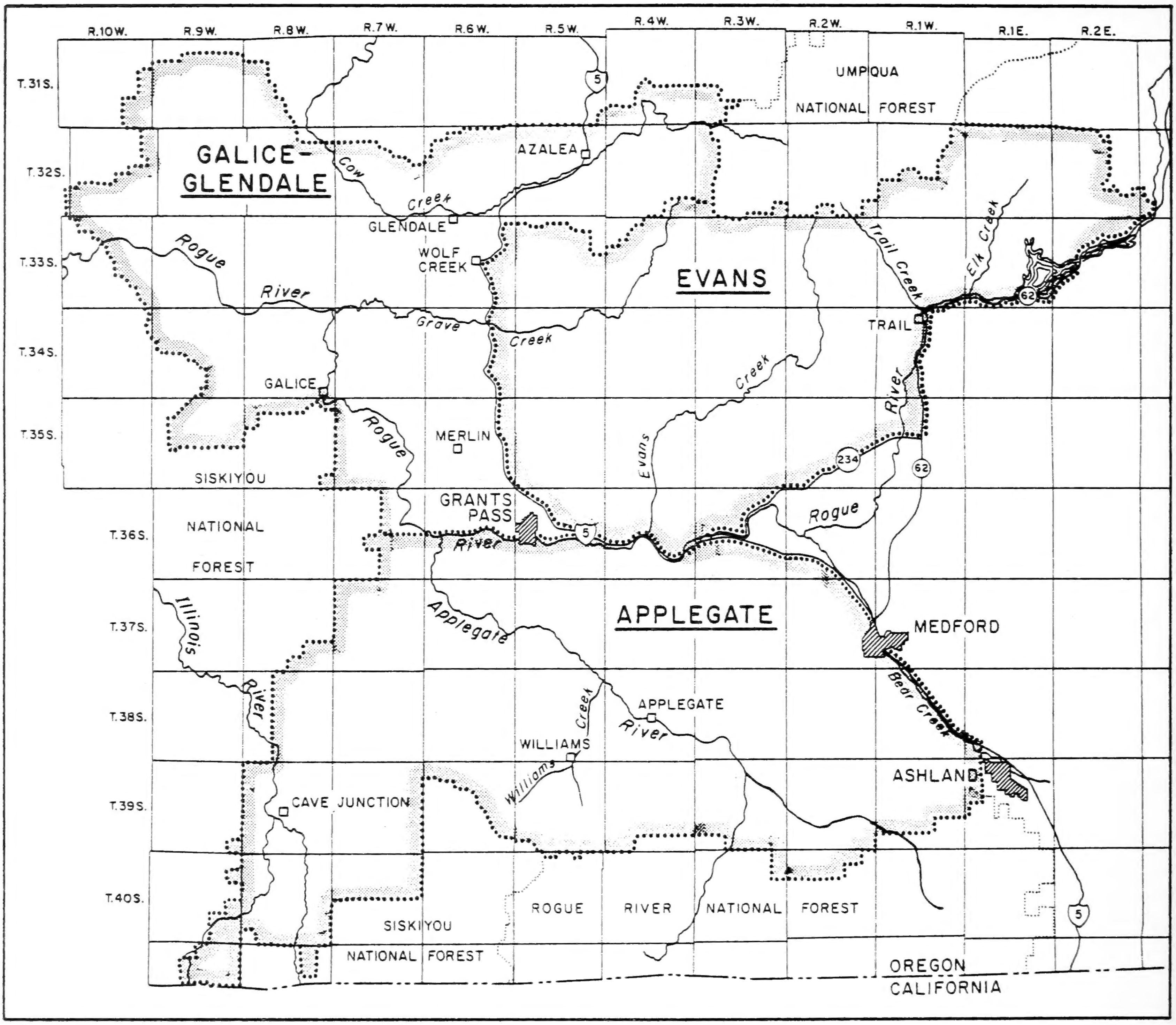

Figure 1.—The Applegate, Evans, and Galice-Glendale areas are located, respectively, to the south, northeast, and northwest of Grants Pass, Oregon.

Survey Methods

Survey methods were designed to answer these specific questions:

1. Of the area cut over in the 1956-71 period, what portion is now at least 30, 50, 70, and 90 percent restocked?
2. What is the composition of the stocking?
   a. Percent of area stocked by individual species?
   b. Percent of stocked area dominated by each species?
   c. Comparative stocking by seedlings of preharvest and postharvest origin?
   d. Portion of total stocking naturally established or artificially established?
3. Does stocking vary with changes in observed environmental variables?
4. What are the major regeneration problems?
5. Where are the chief problem areas?

Sample Selection

Sample plots were located randomly within BLM acreages clearcut or partially cut in the Applegate, Evans, and Galice-Glendale areas during 1956-71. Separately for each geographic area, cutovers were identified by section subdivisions, the forties (40 acres, a sixteenth of a section), in which they occurred. Primarily from photomap information, separate lists were compiled of all BLM forties in which areas of 10 or more contiguous acres had been partially cut or clearcut. If a forty contained at least one clearcut and one partial cut of 10 or more acres, it was entered in both lists. All forties with sufficient cutting were listed, including those where cutting status or system were in doubt.

After candidate forties had been numbered consecutively, tentative samples were selected by using a table of random numbers. Randomly chosen coordinates designating the exact location of the sample point (plot) in chains north and east of the southwest corner were then assigned to each sample forty. When the designated sample point did not occur within cutover acreage, the sample was rejected. In successive random selections, a harvest unit within a forty might be sampled more than once (sampling with replacement), each time at a point designated by a new set of randomly chosen coordinates.

These selection procedures resulted in a generous listing of forties and a consequent high rejection rate when sample points were located in uncut areas, in clearcuts, or did not meet other criteria, such as time since harvest. Rejections in the three geographic areas were largely for the same reasons, so the tally was combined. Disposition of the first 319 candidate samples in partial cuts was as follows:

Plots	Percent	
Sampled		27.3
Rejected:		72.7
Uncut	50.5	
Natural openings or scrub	2.5	
Cut over since 1971	4.1	
Cut over before 1956	1.9	
Clearcut	10.3	
Miscellaneous	3.4	
Total	72.7	100.0

Among the first 182 candidate samples in clearcuts, 25.8 percent were valid samples; 68.1 percent were rejected because the sample point was located in an uncut or partially cut stand; and 6.1 percent were rejected for age of the cutover or for other reasons.

Plots and Subplots

Sample plots were found by hand compass and pacing. A land survey corner or section line marker at roadside was the usual starting point; but occasionally an identified road intersection, ownership boundary, or distinct geographic feature was used.

On each qualifying 2-acre (0.8-ha) sample plot, five circular 4-milacre (1/250-acre; 0.00162-ha) subplots were located at 1-chain (66-ft; 20.1-m) intervals along each of four gridlines. The first line of the grid was extended northward from the beginning point, and adjacent lines were spaced 1 chain apart to the east. The beginning line of the grid was rotated to other cardinal directions starting with east when this was necessary to place the grid within the cutting unit. If a subplot was clearly unsuited for establishment of regeneration, it was not sampled. The affected gridline was then extended a chain in the direction of travel to provide a replacement subplot.

A subplot was considered unsuited for regeneration establishment if any of these conditions prevailed on **more than half** its area:

1. Streambed up to normal high waterlines.

2. Permanent marsh, swamp, or meadow.

3. Road used since 1971.

4. Gravel pit used since 1971.

5. Solid rock, stump, or live tree stem.

6. Area of deep, active erosion.

Subplots were rejected on only 24 of the 134 plots sampled. In total, 42 of 2,680 subplots were rejected, or 1.6 percent. Occurrence of the subplot on an actively used road was the cause for all but 14 rejections.

Data Collected

Each subplot was thoroughly searched for seedlings. Stocking (occurrence of at least one seedling per plot) was determined for each species, but a count for total number was not made. When 1/250-acre (0.00162-ha) subplots are used, observed stocking is based on a full stocking of 250 uniformly distributed trees per acre (618 per ha). Stocking was recorded by class of regeneration: (1) advance—healthy seedlings and saplings up to 8 inches (20 cm) in diameter, that originated before timber harvest; (2) subsequent—healthy seedlings originating after one or more timber harvests and 2 or more years old; and (3) second-year—healthy seedlings still in their second season of growth. A species could have up to three entries per subplot, one for each class. Stocking was also recorded as being from natural seed fall, planting, or direct seeding. The species and class of regeneration most likely to become dominant on the subplot because of size, position, and competitive potential were also noted.

Environmental variables observed on each subplot were aspect, slope, canopy, total ground cover, dominant ground cover, seedbed, and seed source. If one variable—grass, gopher activity, dense canopy, competing vegetation, etc.—was considered a primary help or hindrance to establishment of regeneration after timber harvest, it was also noted. Techniques used to collect and sum descriptive and environmental data are detailed in the appendix, page 70.

Summaries and Analyses

Data were analyzed by several methods to answer the various regeneration questions. Stocking data were summed and their means and standard errors calculated to ascertain current status of regeneration. Regression, correlation, and variance analyses tested relationships between stocking level and various environmental factors. The steps involved are outlined below; details are given with the results they pertain to.

Stocking data for each sample plot were summarized by counting the subplots stocked by any species and by each species of advance, subsequent, and second-year regeneration. Summary tables showing total and other stocking classes were compiled individually for Applegate, Evans, and Galice-Glendale partial cuts and clearcuts. Stocking data from all three areas were also combined as weighted averages to provide a broad view of regeneration status in the Siskiyou part of the Medford District. For individual geographic areas, plots having more than 30-, 50-, 70-, or 90-percent stocking were counted; the totals were expressed as a percentage of plots in the group; and confidence limits were determined for the resulting proportions from tables prepared by Mainland and others (1956). Information on species composition, dominance, and abundance was developed similarly.

Preparation of environmental data used in correlation and multiple regression analyses required the calculation of plot averages for observed variables and those obtained from external sources. Tests for association between independent variables and the stocking per plot found in partial cuts or clearcuts were made for the geographic areas individually and combined for all three by means of the SPSS stepwise multiple regression computer program (Vogelback Computing Center, Northwestern University, version 8.0, June 18, 1979). Associations between some noncontinuous (discrete) independent variables—forest type, soil series, geographic location, etc.—and plot stocking were inferred from statistically demonstrated and observed differences among groupings. Differences among stocking means representing three or more plots per grouping were tested for significance by analysis of variance. Duncan Multiple Range Tests (Duncan 1955) were used to identify specific means that differed significantly.

Stocking

Stocking data for plots in partial cuts and in clearcuts were summed separately to show average stocking, proportion of acreage stocked to a given level, and stocking by individual species. Information on species abundance and potential dominance was also developed.

Average Stocking

Both partial cuts and clearcuts were well stocked in the Applegate, Evans, and Galice-Glendale areas.[2/] Total stocking varied somewhat among areas, but averaged 80.8 $\pm$ 1.9 percent in partial cuts and 76.7 $\pm$ 2.8 percent in clearcuts (table 15, appendix). Total stocking ranged widely, from 30 to 100 percent among both partial cuts and clearcuts.

After logging, the amount of advance regeneration was substantial in partial cuts: It averaged 40-percent stocking in the Applegate area, 52 percent in the Evans area, and 65 percent in the Galice-Glendale area (fig. 2, and table 15, appendix). The stocking present on individual plots ranged from 0 to 100 percent. Advance regeneration constituted just over half the total stocking in Applegate partial cuts, 65 percent in Evans partial cuts, and 75 percent in Galice-Glendale partial cuts. Advance regeneration constituted a highly important component of total stocking in partial cuts because of the amount present and the size of the trees (fig. 3).

[2/]Stocking classes, as defined by the Pacific Northwest Seeding and Planting Committee (Reynolds and others 1953): well stocked, 70-100 percent; moderately stocked, 40-69; poorly stocked, 10-39; and nonstocked, 0-9.

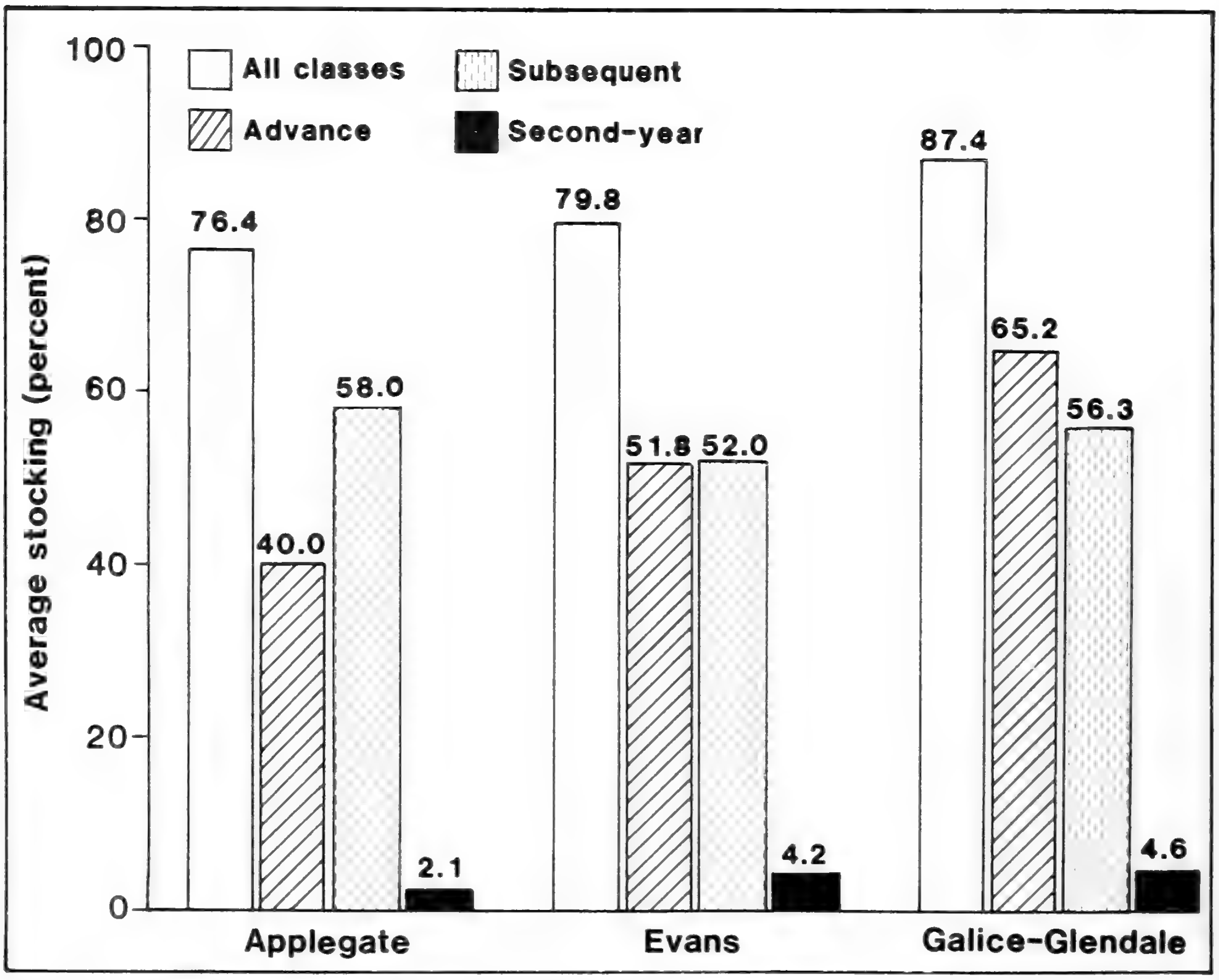

Figure 2.—Regeneration in partial cuts, by class. Data are not additive because more than one class of regeneration was found on many subplots.

Figure 3.—Regeneration established before logging constituted from 50 to 75 percent of total stocking in partial cuts (Douglas-fir and true fir advance regeneration are prominent in the center of the picture).

Advance regeneration was also present in quantity in clearcuts and averaged 25 percent of total stocking (fig. 4, and table 15, appendix). The amount present on individual plots ranged from 0 to 90 percent. About 3 of every 4 clearcuts in the Applegate area had some advance stocking; in the Evans area 4 of 5 did, and in Galice-Glendale 9 of 10 had some advance stocking.

Partial cuts in all three areas were moderately stocked with regeneration that established after logging. Stocking of subsequent regeneration averaged 55.7 $\pm$2.3 percent (figs. 2 and 5, and table 15, appendix). Subsequent stocking on individual plots ranged from 10 to 100 percent. Postlogging regeneration constituted from 64 to 76 percent of total stocking in the three areas if such regeneration is considered the main component rather than a subsidiary component of total stocking.

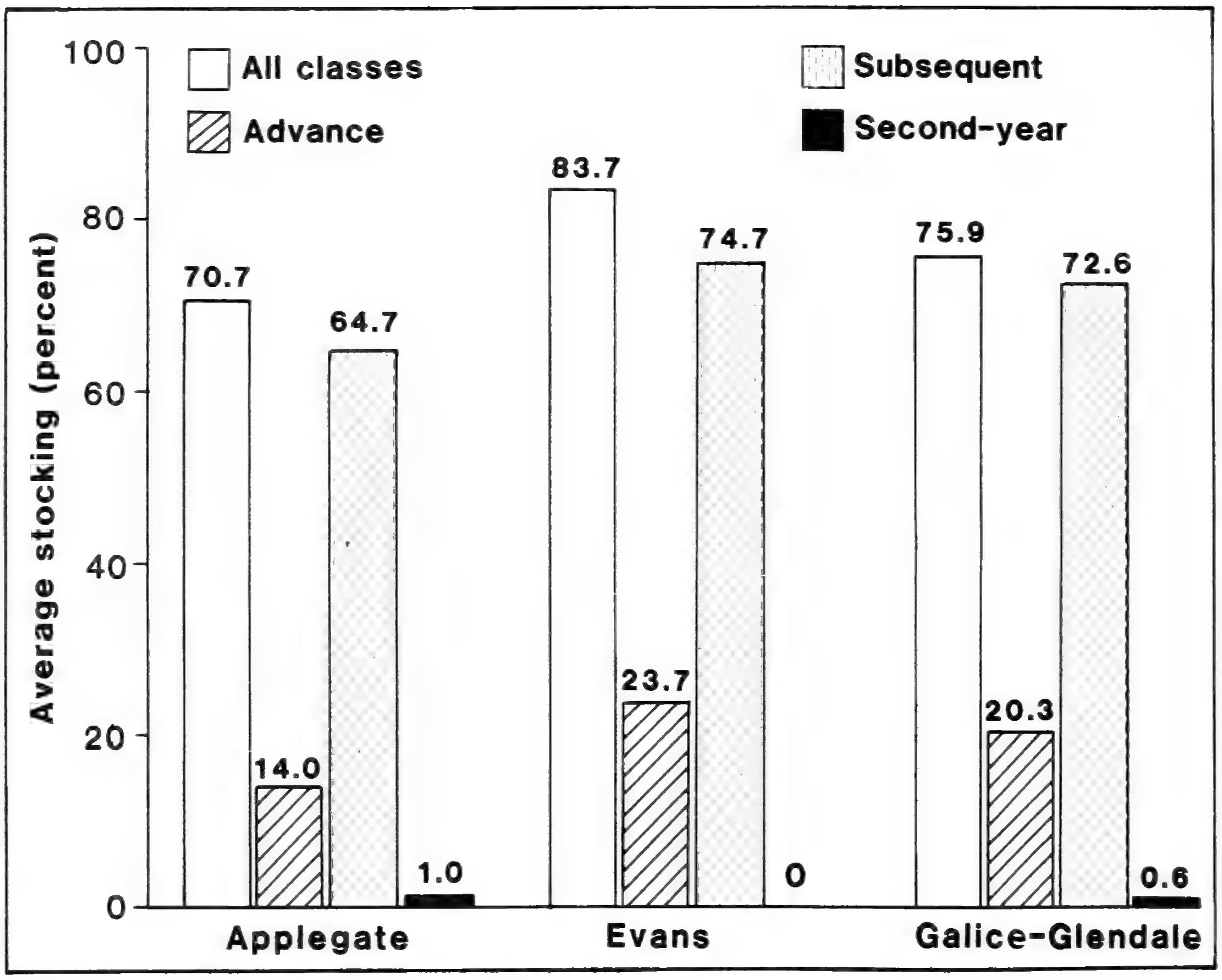

Figure 4.—Regeneration in clearcuts, by class.

Clearcuts had more subsequent regeneration than partial cuts: Stocking averaged 70.7 ±2.9 percent (table 15, appendix). Those in the Applegate area qualified as moderately stocked with an average of 65 percent; in the other two areas they were well stocked at 73 and 75 percent (figs. 4 and 6). Subsequent stocking on individual clearcuts ranged from 25 to 100 percent. Postlogging regeneration constituted 92 percent of total stocking in clearcuts within the three areas if subsequent regeneration is considered the main component of total stocking.

Only limited numbers of second-year seedlings were found in partial cuts or clearcuts (figs. 2 and 4, and table 15, appendix). These were not tallied as part of total stocking because their survival through two full growing seasons had not yet been demonstrated. Their potential for increasing total stocking was very low. Second-year seedlings were found on 30 partial cuts, but only on 7 could second-year seedlings raise stocking by 5 percent; on one, stocking was raised by 15 percent, from 60 to 75 percent. Second-year seedlings were found on only five clearcuts, and on only one could stocking thereby be increased by 5 percent. The primary effect of the continued survival of second-year seedlings will be to increase numbers of seedlings on subplots that are already stocked.

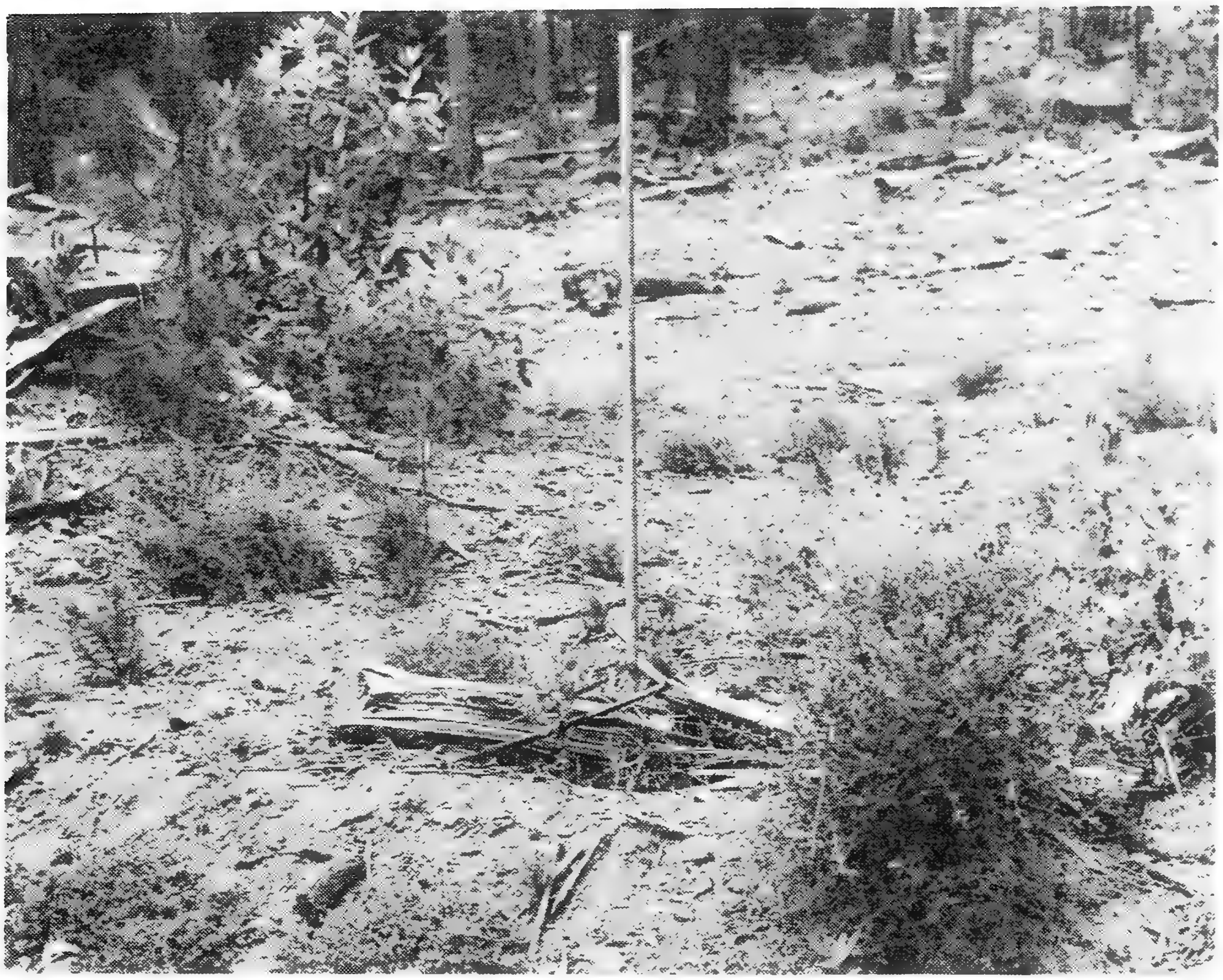

Figure 5.—Partial cuts were moderately stocked with regeneration that established after logging (ponderosa pine to the left; Douglas-fir to the left and right).

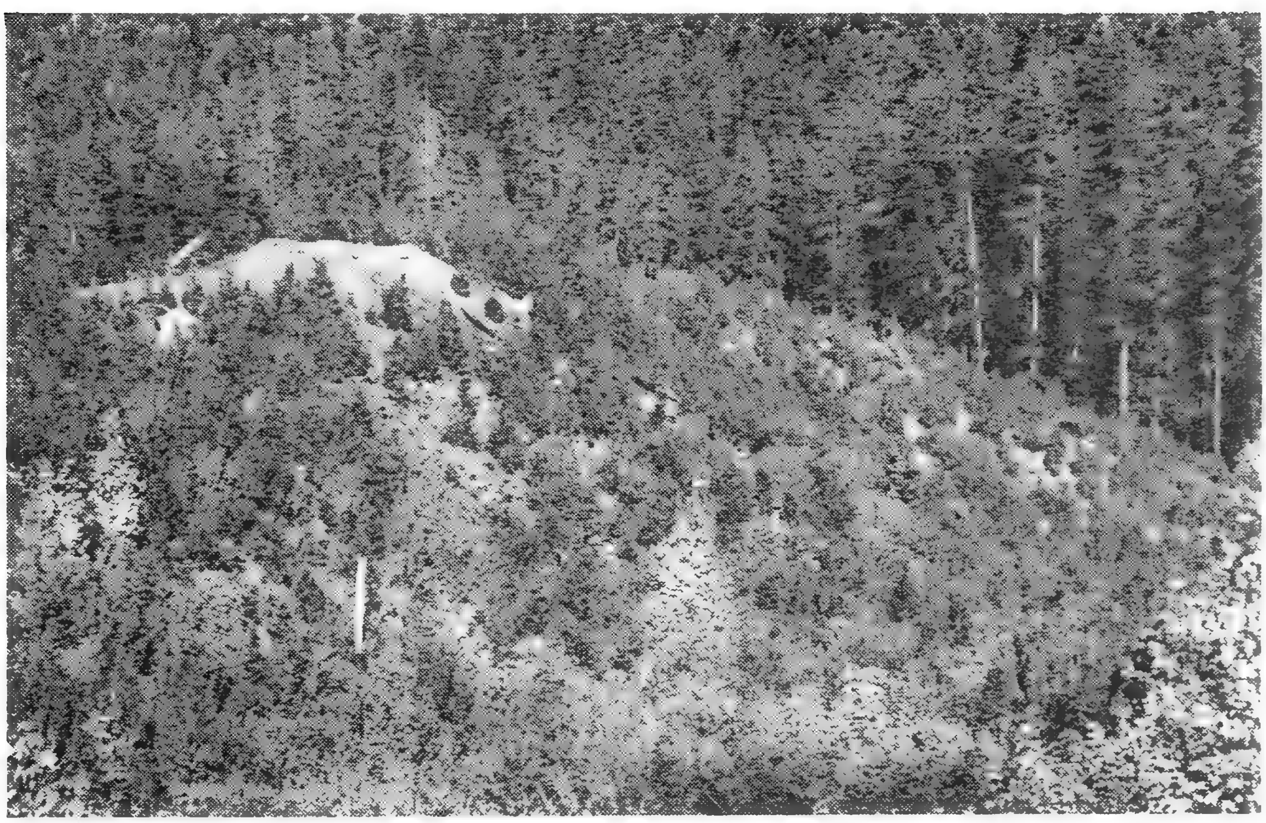

Figure 6.—Many clearcuts were well stocked with subsequent regeneration, which averaged 71 percent (primarily Douglas-fir visible in an Applegate clearcut).

Stocking Levels

The proportion of plots stocked to the 30-, 50-, 70-, and 90-percent levels was determined to augment information on average stocking. To facilitate presentation and illustrate significance of data on stocking levels, let us assume that 50 percent is the dividing line between acceptable and unacceptable stocking. Areas less than 50-percent stocked might then be viewed as requiring additional regeneration effort.

Most of the acreage (94 percent) partially cut in the Siskiyou part of the Medford District between 1956 and 1971 meets the 50-percent or better stocking level (fig. 7, and table 16, appendix). All partial cut acreage in the Evans area meets this level, 96 percent of the acreage in the Galice-Glendale area does, and 89 percent of that in the Applegate area does. Three-fourths of the partial cut acreage meets or exceeds the 70-percent stocking level, and nearly half meets or exceeds the 90-percent stocking level.

About 90 percent of the acreage clearcut in the Siskiyou part of the Medford District between 1956 and 1971 also meets the 50-percent or better stocking level (fig. 8, and table 16, appendix). At the 50-percent stocking level, there is little difference among the Applegate, Evans, and Galice-Glendale areas. Seventy percent of the acreage clearcut meets the 70-percent or better stocking level, but there are differences among areas; Evans has the highest proportion (93 percent) stocked at this level, and the other two areas have substantially lower proportions (59 and 60 percent). Half the clearcut acreage in the Evans and Galice-Glendale areas meets or exceeds a stocking level of 90 percent; one-fourth of the clearcut acreage in the Applegate area does.

Over half the acreage partially cut in the Siskiyou part of the Medford District between 1956 and 1971 has 50-percent or better stocking of advance regeneration (table 17, appendix). The proportion varies, however, by area; it is about one-third for the Applegate area and two-thirds for Evans and Galice-Glendale. In the Galice-Glendale area, about one partial cut in five had as much as 90-percent stocking of advance regeneration. Advance regeneration on one-fourth of the clearcut acreage meets or exceeds the 30-percent stocking level.

About two-thirds of the acreage partially cut in the Siskiyou part of the Medford District between 1956 and 1971 has 50-percent or better stocking of subsequent regeneration (table 18, appendix). The proportion stocked at the 50-percent level varies little among the three areas. About 30 percent of the partially cut acreage meets or exceeds the 70-percent stocking level, but only 10 percent meets or exceeds the 90-percent level. The proportions are markedly greater for clearcut acreage—83 percent meets or exceeds the 50-percent stocking level for subsequent regeneration, nearly 60 percent meets or exceeds the 70-percent level, and one-fourth of the acreage is 90-percent stocked or better. There is also less variation among areas in the proportion of clearcut acreage stocked at the 90-percent level than in proportions of partial cut acreage stocked at this level.

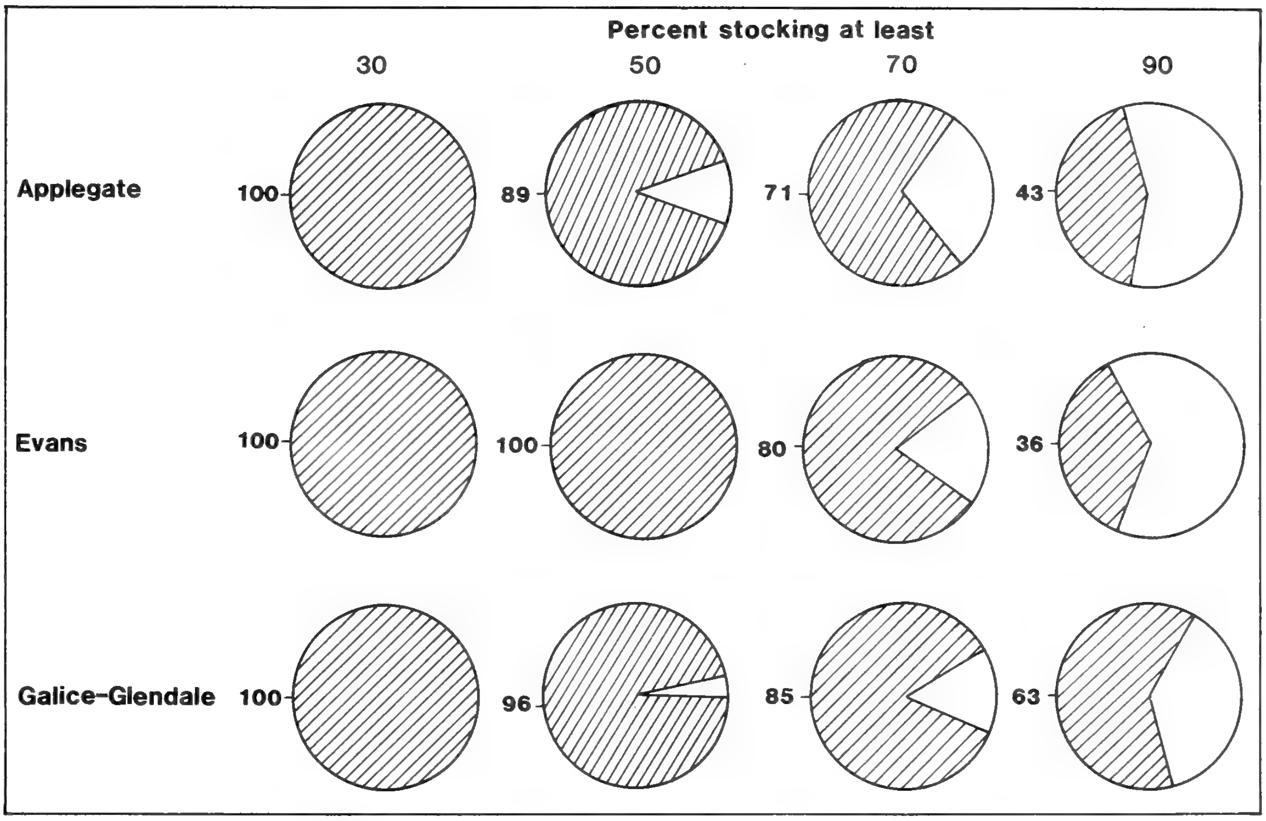

Figure 7.—Proportion of acreage partially cut from 1956 to 1971 that was 30-, 50-, 70-, or 90-percent stocked with regeneration.

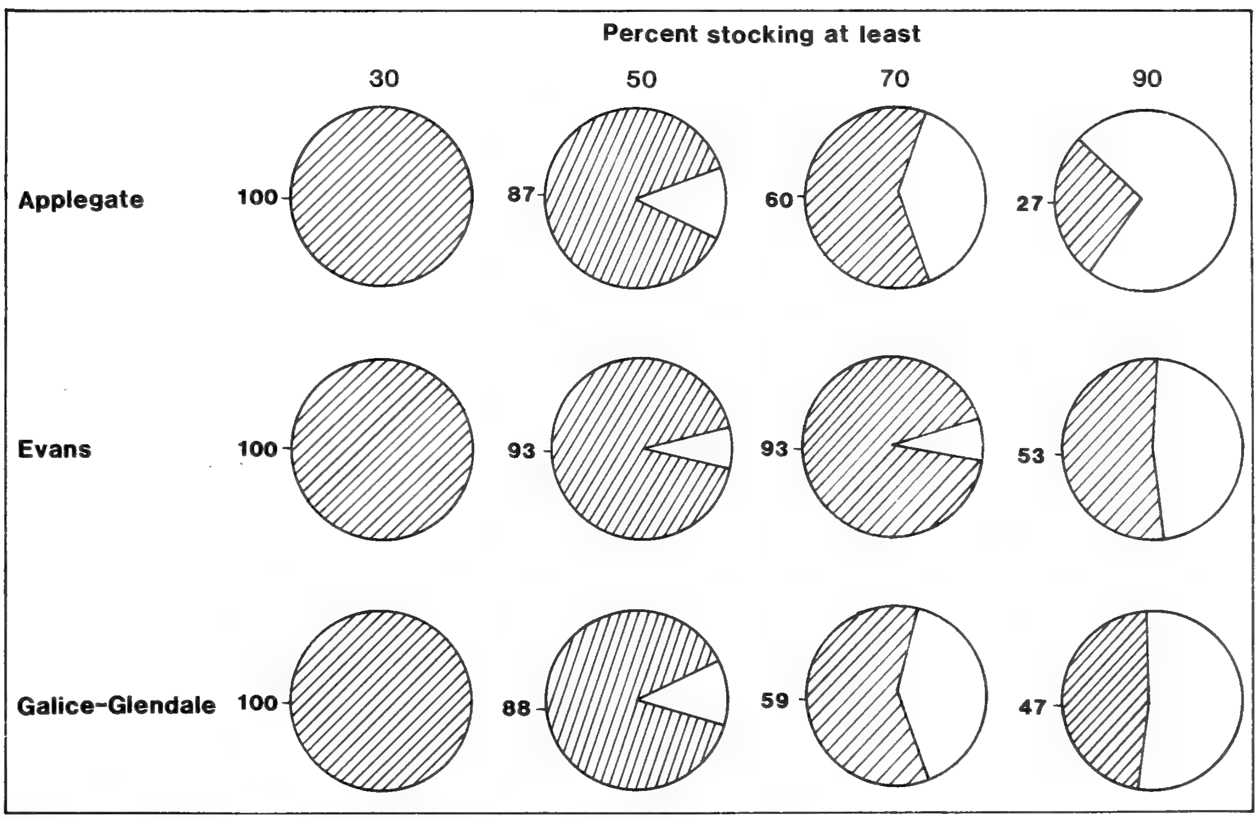

Figure 8.—Proportion of acreage clearcut from 1956 to 1971 that was 30-, 50-, 70-, or 90-percent stocked with regeneration.

Nearly half of the partial cut (45 percent) and clearcut acreage (51 percent) is stocked at or above the 50-percent level with subsequent regeneration of the single most common species, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) (table 19, appendix). Twenty-one percent of the partial cut acreage and 32 percent of the clearcut acreage is stocked at or above the 70-percent level with subsequent Douglas-fir. Acreage stocked with true firs (*Abies* sp.), the second most common species to establish in partial cuts after logging, was minor (table 20, appendix). Twenty-three percent of the clearcut acreage was stocked at the 50-percent level or higher with ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.).

Stand Composition

Many native conifers and hardwoods were found on the plots sampled. The most common conifers included Douglas-fir, true firs, ponderosa pine, sugar pine (*Pinus lambertiana* Dougl.), and incense-cedar (*Libocedrus decurrens* Torr.). True fir regeneration was not identified by species; it varied by locality and included white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.), grand fir (*A. grandis* (Dougl. ex D. Don) Lindl.), and Shasta red fir (*A. magnifica* var. *shastensis* Lemm.). Conifers found in lesser quantities and not distributed universally included western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), Port-Orford-cedar (*Chamaecyparis lawsowniana* (A. Murr.) Parl), Pacific yew (*Taxus brevifolia* Nutt.), western white pine (*Pinus monticola* Dougl. ex D. Don), lodgepole pine (*P. contorta* Dougl. ex Loud.), Jeffrey pine (*P. jeffreyi* Grev. & Balf.), knobcone pine (*P. attenuata* Lemm.), and Brewer spruce (*Picea brewerana* Wats.).

Large hardwoods, generally found in minor amounts, included Pacific madrone (*Arbutus menziesii* Pursh), California black oak (*Quercus kelloggii* Newb.), Oregon white oak (*Q. garryana* Dougl. ex Hook.), canyon live oak (*Q. chrysolepis* Liebm.), tan oak (*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.), giant chinkapin (*Castanopsis chrysophylla* (Dougl.) A. DC.), western serviceberry (*Amelanchier alnifolia* (Nutt.) Nutt.), willow (*Salix* sp.), bigleaf maple (*Acer macrophyllum* Pursh), red alder (*Alnus rubra* Bong.), Oregon ash (*Fraxinus latifolia* Benth.), and California laurel (*Umbellularia californica* (Hook. & Arn.) Nutt.).

Most of the hardwood species listed above were common components of the abundant and varied competing woody vegetation. Additional widespread deciduous brush species included vine maple (*Acer circinatum* Pursh), California hazel (*Corylus cornuta* var. *californica* (A. DC.) Sharp), Pacific dogwood (*Cornus nuttallii* Audubon), ocean-spray (*Holodiscus discolor* (Pursh) Maxim.), western snowberry (*Symphoricarpos occidentalis* Hook.), poison oak (*Rhus diversiloba* T. & G.), thimbleberry (*Rubus parviflorus* Nutt.), and trailing blackberry (*Rubus ursinus* Cham. & Schlecht.). Widespread evergreen brush species included ceanothus (*Ceanothus* sp.), manzanitas (*Arctostaphylos* sp.), Oregon grape (*Berberis* sp.), salal (*Gaultheria shallon* Pursh), and Pacific rhododendron (*Rhododendron macrophyllum* G. Don).

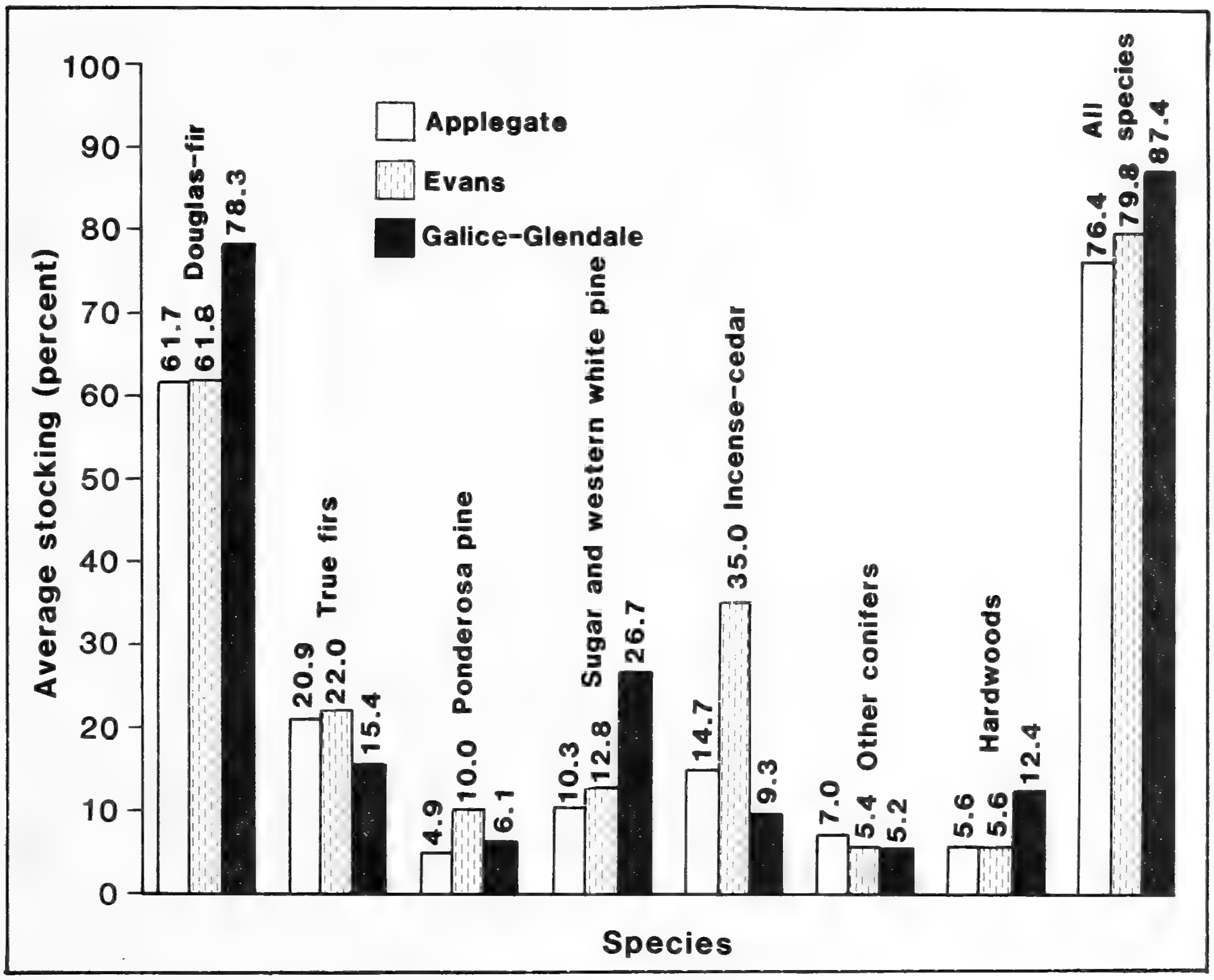

Figure 9.—Average stocking by species in Applegate, Evans, and Galice-Glendale partial cuts.

Douglas-fir predominated by a wide margin among regeneration in partial cuts (fig. 9, and table 21, appendix). Douglas-fir was present on 4 of every 5 (61.7 ÷ 76.4 = 0.808) stocked subplots in the Applegate and Evans areas and on 9 of 10 in the Galice-Glendale area. On the average, true firs, five-needle pines, and incense-cedar were about equally common and occurred on approximately one stocked subplot in four or five, but each species was more prominent than the other two in one area—true firs in Applegate, incense-cedar in Evans, and five-needle pines in Galice-Glendale. Advance or subsequent incense-cedar occurred on nearly half the stocked subplots in the Evans area. Ponderosa pine and hardwoods were found on less than 1 stocked subplot in 10. Ponderosa pine was most common in the Evans area, and hardwoods were most common in the Galice-Glendale area.

Douglas-fir was also the predominant species in clearcuts; it was present on 7 stocked subplots in 10 in the Applegate and Evans areas and approached 9 in 10 in the Galice-Glendale area (fig. 10, and table 21, appendix). Ponderosa pine was the second most common species on stocked subplots in the Applegate and Evans areas, but in Galice-Glendale, true firs and five-needle pines shared that position. In the Evans area, ponderosa pine was present on half of the stocked subplots and incense-cedar on one in five. True firs were present in clearcuts on one stocked subplot or less in five. Hardwoods were most common in Evans clearcuts; they were present on about one stocked subplot in seven.

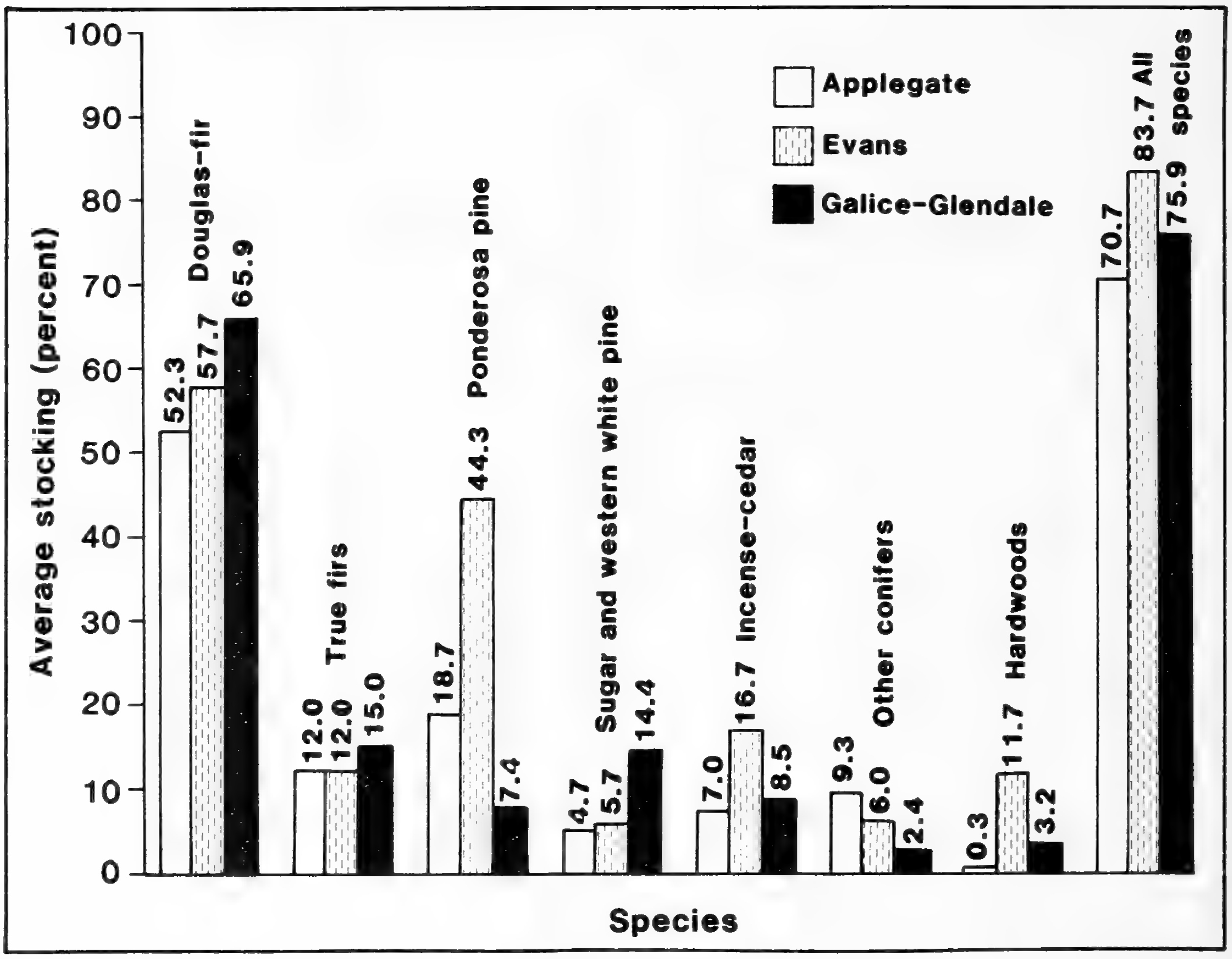

Figure 10.—Average stocking by species in Applegate, Evans, and Galice-Glendale clearcuts.

The predominant species among advance regeneration in both partial cuts and clearcuts was Douglas-fir (table 22, appendix). This species was present on three of every five subplots stocked with advance regeneration in the Applegate and Evans partial cuts and four of five in Galice-Glendale partial cuts. Among the limited advance stocking in clearcuts, Douglas-fir was present on nearly one stocked subplot of three in Applegate and about two of three in Evans and Galice-Glendale. True firs were second most common among advance regeneration in Applegate partial cuts and in all clearcuts, but were exceeded by incense-cedar in Evans partial cuts and by five-needle pines in Galice-Glendale partial cuts. Advance hardwood regeneration was found on only a small number of stocked subplots in partial cuts except for Galice-Glendale where it occurred on nearly one stocked subplot in five. Advance hardwood regeneration was not found on Applegate or Galice-Glendale clearcuts and was present in only minor quantities on Evans clearcuts. In both partial cuts and clearcuts, advance regeneration included a variety of species.

Douglas-fir was also by far the most common species of subsequent regeneration in all cutovers except the Evans clearcuts; it occurred on four of every five subplots stocked with subsequent regeneration (table 23, appendix). In Evans clearcuts, subsequent Douglas-fir and ponderosa pine occurred on three of every five stocked subplots. True firs were the second most common subsequent regeneration in Applegate partial cuts; they were nearly as common as incense-cedar in

Evans partial cuts and were exceeded by five-needle pines in Galice-Glendale partial cuts. Ponderosa pine was the second most common subsequent regeneration in Applegate and Evans clearcuts, but was exceeded by five-needle pines and true firs in Galice-Glendale clearcuts. Hardwoods that established after logging were found on about 1 stocked subplot in 7 in Evans clearcuts and on less than 1 in 10 stocked subplots in other clearcuts and in partial cuts. As with advance regeneration, a variety of species was represented in the subsequent regeneration.

Among second-year seedlings, stocking of Douglas-fir also predominated, except in Evans partial cuts where occurrence of incense-cedar was greater (table 24, appendix). Because stocking of second-year seedlings was low, especially in clearcuts, few trends in species composition are evident. Older seedlings of several hardwood species were present, but no second-year seedlings were found.

As a proportion of stocking by all species in the Applegate and Evans partial cuts, Douglas-fir and ponderosa pine were more abundant among subsequent regeneration than they were among advance regeneration, and true firs, incense-cedar, and five-needle pines were less abundant (tables 22 and 23, appendix). In Galice-Glendale partial cuts, species representation as a proportion of advance and subsequent regeneration was the reverse of the other two areas for ponderosa pine and incense-cedar, about equivalent for Douglas-fir and true firs, and remained the same for five-needle pines. On clearcuts, Douglas-fir and ponderosa pine were represented as a higher proportion of subsequent stocking than of advance stocking, and true firs were the reverse. Five-needle pine and incense-cedar representation as a proportion of advance and subsequent stocking on clearcuts was not consistent among areas.

Dominance

Future composition of the developing stand may be more closely related to the classes of regeneration or species that now dominate stocked subplots than to the number of subplots on which each class or species occurs. For this reason, the class of regeneration and the species dominant on each subplot were tabulated. Second-year seedlings were included as these represent potential when nothing older already dominates the subplot.

Advance regeneration dominated over half the stocked subplots in partial cuts and about 20 percent in clearcuts (fig. 11). Specifically, advance regeneration dominated 50 percent of the stocked subplots in Applegate partial cuts, 62 percent in Evans, and 66 percent in Galice-Glendale. Advance regeneration dominated 17, 18, and 24 percent of the stocked subplots in the Applegate, Galice-Glendale, and Evans clearcuts, respectively. Nearly all other stocked subplots were dominated by subsequent stocking because subplots that contained only second-year seedlings were sparse.

Douglas-fir was the dominant species of regeneration in partial cuts and in clearcuts except in the Evans area (fig. 12). Douglas-fir dominance ranged from 35 percent of the stocked subplots in Evans clearcuts to 72 percent in Galice-Glendale partial cuts. Ponderosa pine dominated a substantial number of subplots in Evans clearcuts (42 percent) and in Applegate clearcuts (20 percent). Dominance on the rest of the stocked subplots was shared among several species and varied among areas.

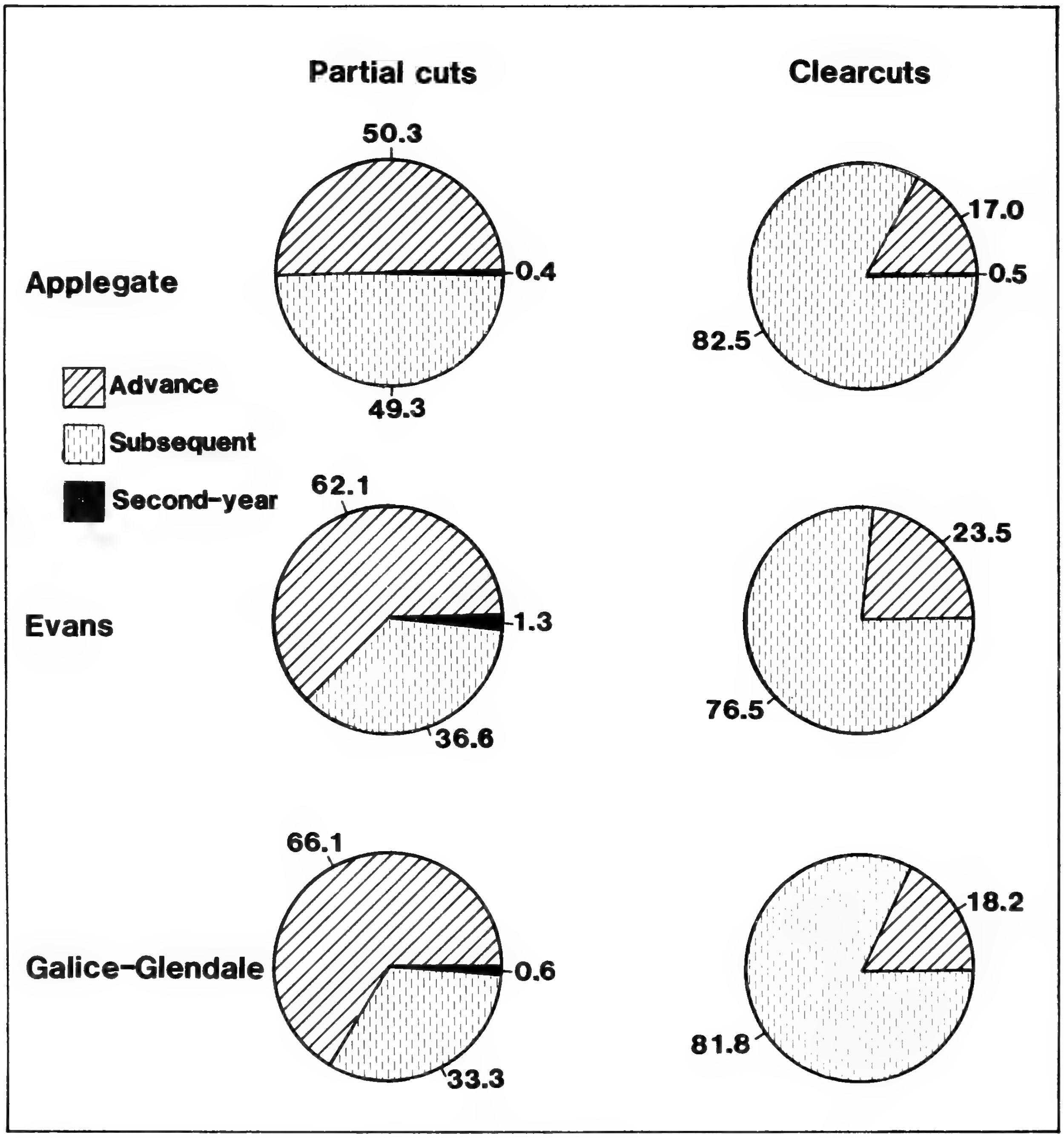

Figure 11.—Advance regeneration dominated more than half of the stocked subplots in partial cuts.

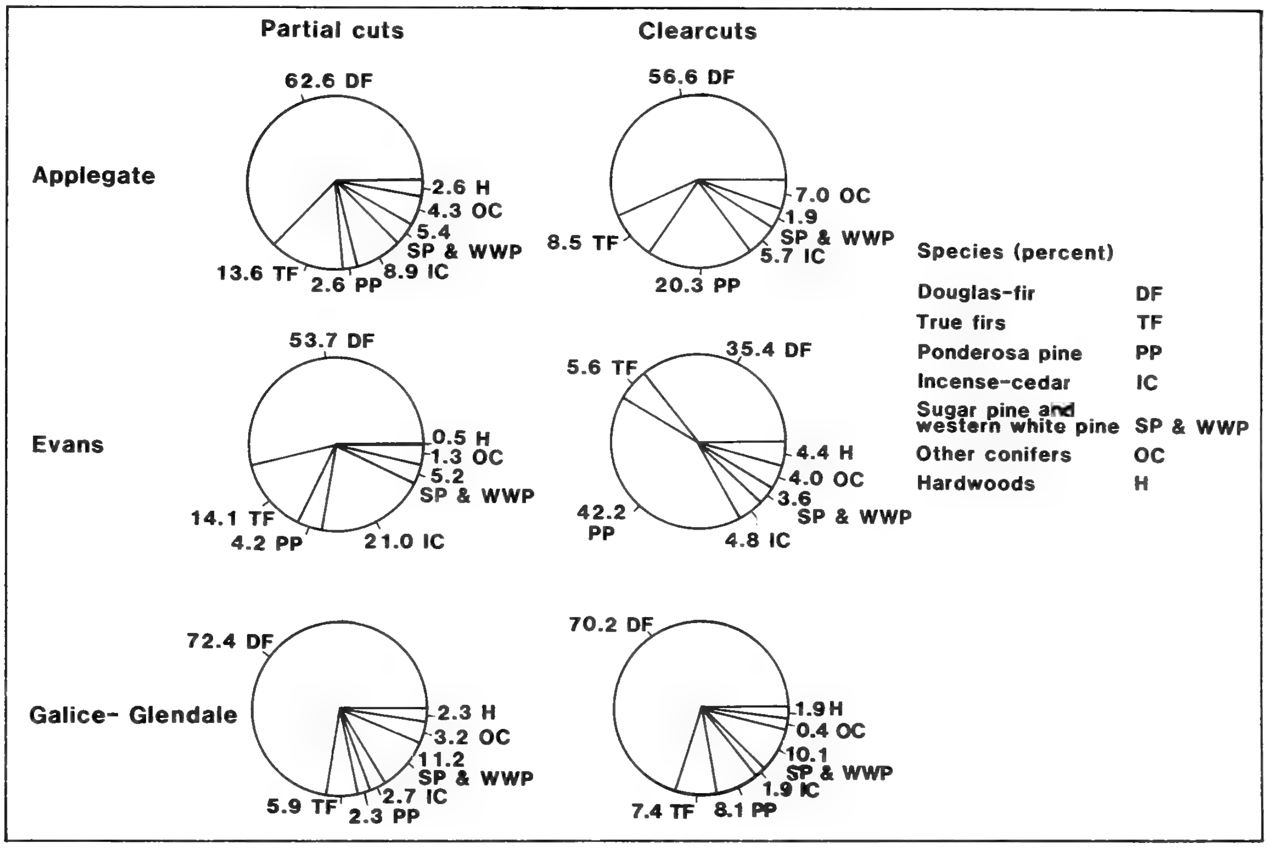

Figure 12.—Douglas-fir was dominant on a majority of stocked subplots.

Species Abundance

In this survey, the presence or absence of seedlings was determined rather than the total number. Because each subplot was searched for individual species, however, some insight on stand mixtures can be gained from the stocking data.

Species mixtures were common in all areas, but their makeup differed somewhat by area and harvest method. More than half the stocked subplots in Applegate partial cuts and Applegate and Galice-Glendale clearcuts contained a single species; elsewhere, a majority of subplots contained more than one species (table 1). About one-third of all stocked subplots contained two species and 16 percent contained three or more species (fig. 13). Up to six species were found on single subplots in Evans clearcuts and partial cuts. Widespread intermixture of species provides opportunities for flexible management of the developing stand.

Presence of more than one species also provides direct evidence that many subplots were stocked with more than one tree. Combining data from all cutovers sampled, 51 percent of the stocked subplots had more than one conifer species. The percentage of subplots that had more than one conifer of any species was undoubtedly much higher.

Table 1—Number of species per stocked subplot in partial cuts and clearcuts

Species per subplot	Applegate	Evans	Galice-Glendale
	Geographic area		
	- - - - Percent of stocked subplots - - - -		
		PARTIAL CUTS	
1	53.6	41.1	42.5
2	33.5	33.9	41.1
3	8.6	19.1	14.7
4	4.1	4.7	1.3
5	.2	1.0	.4
6	0	.2	0
Total	100.0	100.0	100.0
		CLEARCUTS	
1	61.8	43.8	58.9
2	29.3	35.9	27.9
3	8.0	14.3	12.8
4	.9	4.8	.4
5	0	.8	0
6	0	.4	0
Total	100.0	100.0	100.0

Figure 13.—At least two species were found on 51 percent of all stocked subplots (ponderosa pine in foreground, Douglas-fir in background).

Environmental Relationships

Regeneration survey objectives included a search for covariation of environmental factors and seedling stocking and the identification of problem areas. Two kinds of analysis were used: (1) a comparison of means by analysis of variance after stocking data were sorted on the basis of discontinuous environmental variables such as forest type and soil series; and (2) correlation and regression analyses testing for associations between plot stocking and independent environmental variables of a continuous nature—for example, elevation, slope, and canopy. Environmental information obtained for the three areas is presented before results of the two types of analysis are given.

Environments in the Applegate, Evans, and Galice-Glendale areas differ in several important respects. The nature of the forests and associated vegetation reflect these differences, but a systematic comparison of environmental factors as determined for sample plots more clearly brings out extent of the differences.

Geographic Characteristics

Geographic location relative to influencing climatic and topographic features is one of the foremost differences among the areas. Most of the Applegate and Evans areas are located farther inland than is the Galice-Glendale area (fig. 1). The Applegate area comprises northerly approaches to high peaks of the Klamath Mountains. In this position, the Applegate area has drainages flowing primarily northwesterly to the Rogue River and is bounded by higher mountains to the west, south, and east. The Evans area, located north and east of the Applegate area, has the inverse pattern with most drainages flowing south or west to the Rogue River. The southerly part of the Galice-Glendale area is drained by lower reaches of the same westerly flowing streams as the Evans area; the northerly part drains into Cow Creek, which turns in a large arc from southwestward to flow northeastward into the South Umpqua River. The Evans area is bounded by high mountains on the west that are located in and beyond the Galice-Glendale area and also by high mountains to the north and east. All areas include valley bottoms, ridge tops, and mountain peaks.

Most of the acreage sampled in each area was located on sloping, dissected terrain. Slopes of plots averaged 46 percent in Applegate and Evans partial cuts but only 33 percent in Galice-Glendale partial cuts (table 2). The gentlest slope sampled in partial cuts averaged 5 percent; the steepest, 75 percent. Slopes of plots in clearcuts were similar to those in partial cuts except in the Galice-Glendale area where they were steeper, averaging 41 percent (table 3). Slopes ranged from 10 to 68 percent among plots in clearcuts.

Plots sampled in the Applegate area were at somewhat higher elevations than those in the Evans and Galice-Glendale areas (tables 2 and 3). The average elevations of sample plots in Applegate, Evans, and Galice-Glendale partial cuts were, respectively, 3,047, 2,926, and 2,537 feet (929, 892, and 773 m); the highest plot was located at 4,400 feet (1 341 m), the lowest at 1,200 feet (366 m). For the respective areas, plots in clearcuts averaged 3,335, 2,613, and 2,862 feet (1 017, 796, and 872 m). Among clearcuts, the highest plot was located at 4,600 feet (1 402 m), the lowest at 1,300 feet (396 m).

Table 2—Physical characteristics of sampled areas in partial cuts

Characteristic	Applegate	Evans	Galice-Glendale
	Geographic area		
		Number of areas	
Drainage:			
Evans Creek	0	14	0
Applegate River	12	0	0
Williams Creek	11	0	0
Middle Rogue	3	1	9
Illinois River	7	0	1
Grave Creek	0	3	6
East Cow Creek	0	0	6
West Cow Creek	0	0	5
Trail Creek	0	4	0
Elk Creek	0	3	0
Bear Creek	2	0	0
Total	35	25	27
Predominant aspect:			
SE to W	5	16	8
NW to E	30	9	19
Soil series: 1/			
370	8	4	2
371	2	6	6
372	3	0	2
380	2	1	4
381	0	0	6
701	0	0	1
706	0	3	0
718	9	1	0
719	2	1	2
721	2	2	3
722	2	0	0
732	0	1	0
741	0	5	0
781	3	0	1
824	1	1	0
861	1	0	0
Radiation index:			
Average	.3969	.4726	.4433
Range	.2312-.5294	.2300-.5810	.2576-.5577
		Feet	
Elevation: 2/			
Average	3,047	2,926	2,537
Range	1,540-4,400	1,570-3,820	1,200-3,450
		Inches	
Precipitation: 3/			
Average annual	34.7	39.6	62.4
Range	20-58	18-54	38-99
		Percent	
Slope:			
Average	46.0	45.7	33.3
Range	5-72	11-75	9-61
Seedbed disturbance:			
Average	43.9	49.0	48.3
Range	10-90	20-80	20-90

1/ See deMoulin and others (1975) for descriptions of numbered soil series.

2/ To convert feet to meters, multiply by 0.305.

3/ To convert inches to centimeters, multiply by 2.54.

Table 3—Physical characteristics of sampled areas in clearcuts

Characteristic	Applegate	Evans	Galice-Glendale
	Geographic area		
		Number of areas	
Drainage:			
Evans Creek	0	10	0
Illinois River	8	0	0
Middle Rogue	0	2	8
Applegate River	4	0	0
East Cow Creek	0	0	3
West Cow Creek	0	0	5
Williams Creek	3	0	0
Elk Creek	0	2	0
Grave Creek	0	1	1
Total	15	15	17
Predominant aspect:			
SE to W	3	1	8
NW to E	12	14	9
Soil series: 1/			
370	4	1	2
371	1	3	11
372	1	0	0
380	1	0	1
381	0	0	3
712	0	2	0
718	3	0	0
719	1	1	0
721	0	3	0
722	0	3	0
731	0	1	0
741	0	1	0
824	3	0	0
861	1	0	0
Radiation index:			
Average	.4019	.3972	.4323
Range	.2958-.5225	.3064-.5141	.2599-.5786
		Feet	
Elevation: 2/			
Average	3,335	2,613	2,862
Range	2,360-4,600	1,880-3,720	1,300-4,040
		Inches	
Precipitation: 3/			
Average annual	40.3	41.3	76.3
Range	22-58	20-52	45-99
		Percent	
Slope:			
Average	44.3	50.7	41.4
Range	15-66	19-67	10-68
Seedbed disturbance:			
Average	73.3	67.7	66.8
Range	35-95	30-100	5-100

1/ See deMoulin and others (1975) for descriptions of numbered soil series.

2/ To convert feet to meters, multiply by 0.305.

3/ To convert inches to centimeters, multiply by 2.54.

It is unlikely that the length of growing season or temperature pattern of the three areas are markedly different. The largest difference in average elevation for plots sampled in the three areas was 722 feet (220 m), but even this difference may be mitigated to some extent as the highest average elevation corresponds with the southernmost area, Applegate. The range of elevations sampled indicates that plots represented hot, low-elevation sites as well as cooler, higher elevation sites in each area. Application of the adiabatic gradient (5.6 °F per 1,000 feet or 1 °C per 100 m) provides some insight on the relative temperatures at different elevations. When summer temperatures register 100 °F (38 °C) in the shade at the 1,300-foot (396-m) elevation near Medford, temperatures are about 90 °F (32 °C) at 3,000 feet (914 m) and 85 °F (29 °C) at 4,000 feet (1 219 m).

Limited records indicate that the Galice-Glendale area receives substantially more precipitation than the other two areas receive (tables 2 and 3). As extrapolated from a small-scale isohyet map, which was only a first approximation of rainfall distribution in the areas, precipitation averages 62 inches (158 cm) per year for partial cuts in Galice-Glendale, about 40 inches (101 cm) for those in the Evans area, and 35 inches (88 cm) for those in the Applegate area. Precipitation on the clearcuts sampled is somewhat higher; it averages 76 inches (194 cm) in Galice-Glendale, 41 inches (105 cm) in Evans, and 40 inches (102 cm) in Applegate. Judged by data for plot locations, precipitation ranges from 38 to 99 inches (97 to 251 cm) in Galice-Glendale, 18 to 54 inches (46 to 137 cm) in Evans, and 20 to 58 inches (51 to 147 cm) in Applegate.

Closer proximity to the coast accounts for the higher precipitation levels in the Galice-Glendale area than in the other two areas. Even parts of the Galice-Glendale area are, however, subject to rain shadow effects because the area is bordered by higher peaks on the south and west. Rain shadow effects probably influence much of the Applegate and Evans areas because their midelevation topography is bounded by higher peaks.

The cutovers sampled were unequally distributed by aspect (tables 2 and 3). Twice as many partial cuts were located on northerly aspects (NW to E) as on southerly aspects (SE to W). Among clearcuts, the proportion was 3 to 1. The proportion varied markedly by area, however, and so did the radiation index values, which are based on slope and aspect combined. For example, more partial cuts in the Evans area were on southerly aspects (higher radiation values) than on northerly aspects (lower values), and the radiation index averaged higher there than for partial cuts in other areas or for clearcuts. Partial cuts in the Applegate area and clearcuts in the Evans area had the lowest, and equal, average radiation index values.

Sample plots in all three areas were located on loam soils but the gravel content, color, and depth of the soils vary substantially:

	Surface		Depth	
Series	Texture	Color	Surface (Inches)[3]	Total (Inches)[3]
370	Gravelly loam	Very dark grayish brown	8	45
371	Gravelly loam	Very dark grayish brown	7	35
372	Very gravelly loam	Dark yellowish brown	4	18
380	Clay loam	Dark brown	9	55
381	Gravelly clay loam	Dark reddish brown	7	34
701	Very gravelly loam	Brown	4	13
706	Clay loam	Dark brown	13	36
712	Gravelly clay loam	Brown	5	52
718	Very gravelly loam	Dark brown	8	34
719	Clay loam	Dark reddish brown	9	50
721	Sandy loam	Dark yellowish brown	10	30
722	Loam	Dark brown	10	65
731	Gravelly loam	Dark reddish brown	8	30
732	Very gravelly loam	Brown	4	16
741	Loam	Dark reddish brown	10	55
781	Loam	Brown	8	34
824	Very gravelly loam	Dark brown	8	36
861	Sandy loam	Brown	11	34

All are well-drained except series 706 and 712 which are rated as moderately well drained, and 721 and 861, which are rated as excessively well drained. Most of the soils are of metamorphic origin but four are of volcanic origin (706, 731, 732, and 741) and three are of granitic origin (721, 722, and 861).

Over one-third of the plots in partial cuts and in clearcuts were located on soils with a total depth of 45 inches (114 cm) or greater. About half of the plots were located on medium-depth soils, 31 to 44 inches (79 to 112 cm) deep. Only 16 percent of the plots in partial cuts and 11 percent of the plots in clearcuts were on soils 30 inches (76 cm) deep or less. The proportion of plots on deep, medium, and shallow soils was not notably different among the three geographic areas.

Soil series was determined from District soil maps (deMoulin and others 1975). It is likely, but not absolutely certain, that the 2-acre (0.8-ha) plot sampled at each location was located on soil typical of the mapped series.

During logging, about two-thirds of the seedbed surface, on the average, was disturbed in clearcuts as judged by evidence still visible several years later (table 3). Slightly less than half the seedbed surface was disturbed in partial cuts (table 2). Seedbed disturbance on individual clearcuts ranged from 5 to 100 percent; for partial cuts from 10 to 90 percent. The average amount of seedbed disturbance varied little among the three geographic areas.

[3] See footnote 3, table 2.

Most seedbed disturbance resulted from logging; site preparation by means of slash burning was limited. Logs on about half of the clearcuts in each geographic area were yarded by tractor, on the other half by cable systems. Cable systems were used in only 11 partial cuts; 8 of these were in the Applegate area. Slash was burned in two partial cuts; it was left unburned in all the rest. Slash was not burned in 43 percent of the clearcuts, was spot burned in 28 percent, and was broadcast burned in the rest. All three options were used in each geographic area.

Vegetation Characteristics

Plots sampled in the three geographic areas were located in the Douglas-fir, sugar pine, pine mixture, and ponderosa pine forest types. Forest type at each plot location was determined from Forest Survey maps prepared in the 1940's. Thus, the classification antedates any compositional changes caused by logging. For study purposes, the mapped subdivisions of each type were not kept separate.

In both partial cuts and clearcuts, sample plots were located predominantly in the Douglas-fir type—four times out of five (tables 4 and 5). The sugar pine type was the only other type represented by an appreciable number of plots.

On the average, clearcuts were older than partial cuts, 11 years as compared to 7. Average age of both partial cuts and clearcuts was highest in the Evans area and lowest in the Applegate area. By design, all sample areas had been logged at least 2 years earlier and none more than 20 years earlier.

Overstory canopy in Applegate, Evans, and Galice-Glendale partial cuts averaged, respectively, 48, 45, and 53 percent (table 4 and fig. 14). The means for 20 visual estimates of canopy per individual plot ranged most widely in Galice-Glendale, from 19 to 80 percent. Scattered residual trees were sometimes present on clearcuts, but young trees and shrubs taller than waist high constituted most of the canopy that ranged from 7 to 89 percent (table 5). Clearcuts in the Applegate area averaged the least canopy, 20 percent; in the Evans and Galice-Glendale areas, clearcuts averaged about one-third canopy.

Total ground cover was somewhat more dense in clearcuts than in partial cuts; averages were 58 vs. 52 percent in the Applegate area, 63 vs. 48 percent in Evans, and 76 vs. 59 percent in Galice-Glendale. For individual plots, the amount of ground cover ranged from 18 to 93 percent in partial cuts and from 26 to 88 percent in clearcuts. Woody perennials dominated the ground cover on 94 percent of all plots (fig. 15); herbaceous cover dominated the remainder.

Over 90 percent of the subplots examined in partial cuts were located within 50 feet (15 m) of a seed tree; but in clearcuts, only 10 percent were within 50 feet of a seed tree. Douglas-fir was the predominant species of seed tree in all areas and for both partial cuts and clearcuts. Incense-cedar was the predominant seed tree on 5 plots, true firs on 4, and a mixture of other conifers on 12 plots. On four of every five plots examined in partial cuts, at least two species were represented among the closest seed trees; for plots in clearcuts, two of every three.

Table 4—Vegetative characteristics of sampled areas in partial cuts

Characteristic	Applegate	Evans	Galice-Glendale
	Geographic area		
		Number of areas	
Forest type:			
Douglas-fir	28	22	20
Sugar pine	5	1	7
Ponderosa pine	1	2	0
Pine mixture	1	0	0
Total	35	25	27
Dominant cover:			
Woody perennial	30	24	26
Herbaceous	5	1	1
Main seed source:			
Douglas-fir	32	23	24
Incense-cedar	0	2	0
True fir	2	0	0
Other species	1	0	3
		Years	
Time since harvest:			
Average	6.1	8.9	7.1
Range	2-18	3-20	4-18
		Percent	
Canopy:			
Average	48.0	44.7	52.9
Range	21-67	23-67	19-80
Ground cover:			
Average	52.0	47.6	59.4
Range	27-77	21-76	18-93
Seed source within 50 feet:			
Average	98.4	95.6	77.8
Range	85-100	70-100	30-100

Table 5—Vegetative characteristics of sampled areas in clearcuts

Characteristic	Applegate	Evans	Galice-Glendale
	Geographic area		
		Number of areas	
Forest type:			
Douglas-fir	14	14	10
Sugar pine	1	0	7
Pine mixture	0	1	0
Total	15	15	17
Dominant cover:			
Woody perennial	15	14	17
Herbaceous	0	1	0
Main seed source:			
Douglas-fir	15	8	11
True fir	0	1	1
Incense-cedar	0	3	0
Other species	0	3	5
		Years	
Time since harvest:			
Average	8.9	12.3	11.8
Range	4-12	8-18	4-17
		Percent	
Canopy:			
Average	20.1	32.5	35.9
Range	7-38	11-61	11-89
Ground cover:			
Average	57.9	63.3	76.2
Range	26-81	49-79	58-88
Seed source within 50 feet:			
Average	4.3	23.7	4.1
Range	0-20	0-75	0-45

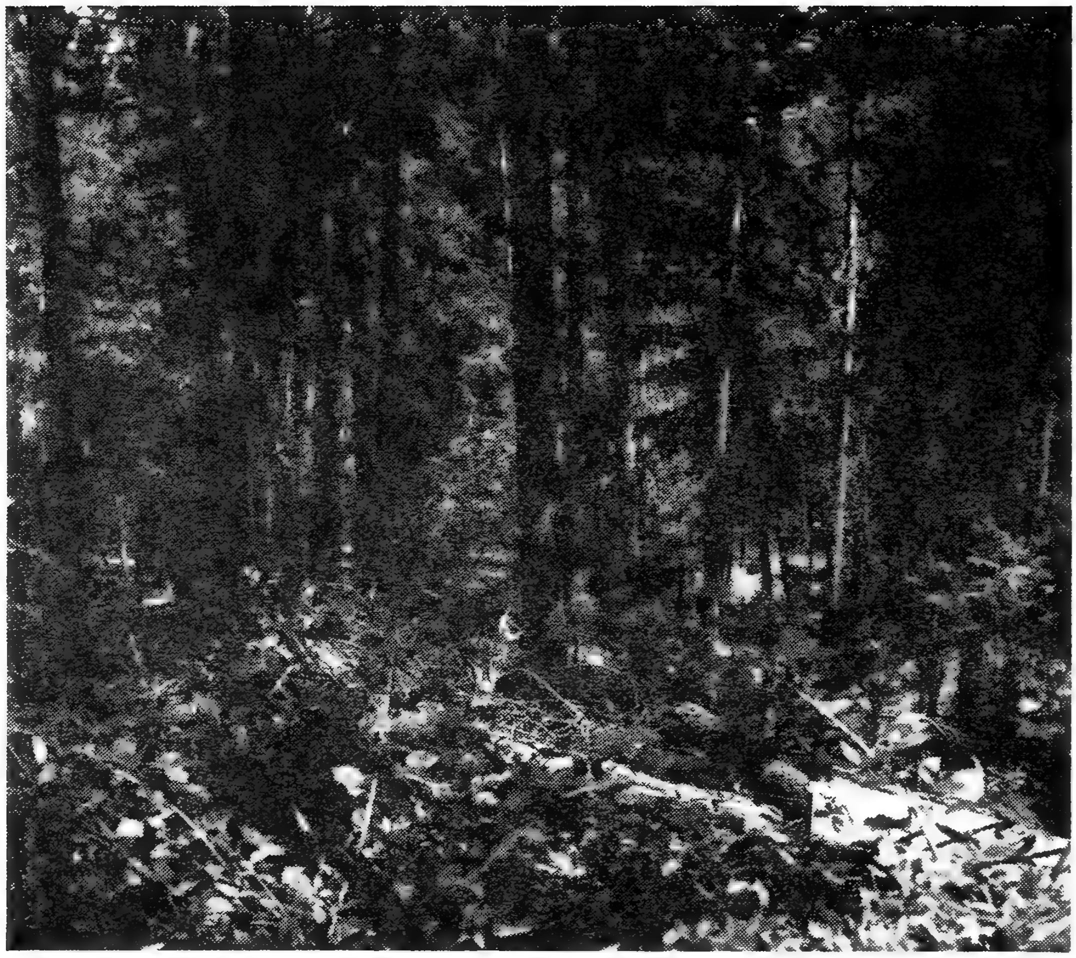

Figure 14.—Overstory canopy in partial cuts averaged about 50 percent but varied greatly within and among plots.

Figure 15.—Woody perennials dominated the ground cover on 94 percent of the plots.

Stocking by Forest Type

Sample plots were sorted by the forest types in which they occurred. Stocking averages for the four classes of regeneration—all, advance, subsequent, and second-year—were then determined for each type, cutting method, and area. Differences in average stocking, among means that were based on three or more plots per type and area, were tested for significance by analysis of variance and Duncan Multiple Range Tests (Duncan 1955). Although forest types are not represented by an equal number of plots and some groupings have insufficient data, the demonstrated statistical differences and the consistency of various differences provide useful insights.

In partial cuts, total stocking, advance stocking, and subsequent stocking averaged significantly lower in the Douglas-fir forest type than in the sugar pine forest type (table 6). The statistically significant differences were substantial, 13 to 21 percent, as were some others where the differences did not quite qualify at the 10-percent significance level (in Applegate—advance stocking at the 12-percent significance

Table 6—Average and range of stocking by forest type in Applegate, Evans, and Galice-Glendale partial cuts

Area and forest type	Sample plots	Regeneration class 1/							
		All		Advance		Subsequent		Second-year	
		Average	Range	Average	Range	Average	Range	Average	Range
	Number	Percent stocking							
Applegate:									
Douglas-fir	28	72.9b	30-100	36.6	0-85	55.5	20-95	2.3	0-10
Sugar pine	5	94.0b	85-100	57.0	25-80	71.0	55-95	2.0	0-5
Ponderosa pine	1	80.0	--	30.0	--	75.0	--	0	--
Pine mixture	1	85.0	--	60.0	--	45.0	--	0	--
Total or average	35	76.4	30-100	40.0	0-85	58.0	20-95	2.1	0-10
Evans:									
Douglas-fir	22	79.8	50-95	51.1	5-95	50.7	15-90	3.4	0-25
Sugar pine	1	90.0	--	70.0	--	65.0	--	20.0	--
Ponderosa pine	2	75.0	60-90	50.0	40-60	60.0	50-70	5.0	0-10
Total or average	25	79.8	50-95	51.8	5-95	52.0	15-90	4.2	0-25
Galice-Glendale:									
Douglas-fir	20	85.8	45-100	63.8	20-100	53.8	10-100	5.8	0-35
Sugar pine	7	92.1	65-100	69.3	35-95	63.6	35-75	1.4	0-5
Total or average	27	87.4	45-100	65.2	20-100	56.3	10-100	4.6	0-35
Areas combined:									
Douglas-fir	70	78.7c	30-100	48.9a	0-100	53.5a	10-100	3.6	0-35
Sugar pine	13	92.7c	65-100	64.6a	25-95	66.5a	35-95	3.1	0-20
Ponderosa pine	3	76.7	60-90	43.3	30-60	65.0	50-75	3.3	0-10
Pine mixture	1	85.0	--	60.0	--	45.0	--	0	--
Total or average	87	80.8	30-100	51.2	0-100	55.7	10-100	3.5	0-35

1/ Means followed by the same letter differ significantly--a, at 10-percent probability level; b, 5-percent; and c, 1-percent.

level; subsequent stocking at the 14-percent level). Even averages for individual areas (where statistical significance could not be demonstrated) consistently supported the conclusion that stocking was greater in the sugar pine forest type. No stocking trends were indicated by the sparse amounts of second-year seedlings nor by the limited data for the ponderosa pine and pine mixture forest types.

Stocking levels for the Douglas-fir and sugar pine types were generally reversed in clearcuts relative to those in partial cuts (table 7); stocking in the Douglas-fir type was higher. The differences in total stocking and subsequent stocking in the Galice-Glendale area were statistically significant at the 10-percent level; total stocking for areas combined at the 16-percent level. Pine types were not represented sufficiently in the Applegate and Evans areas to allow meaningful comparisons.

Even though there were demonstrated statistical differences in average stocking among forest types and more could be proved at probability levels over 10 percent, it is important to recognize that stocking ranged widely among plots in every type (tables 6 and 7).

Table 7—Average and range of stocking by forest type in Applegate, Evans, and Galice-Glendale clearcuts

Area and forest type	Sample plots	All: Average	All: Range	Advance: Average	Advance: Range	Subsequent: Average	Subsequent: Range	Second-year: Average	Second-year: Range
		Regeneration class 1/							
	Number	Percent stocking							
Applegate:									
Douglas-fir	14	69.3	30-100	15.0	0-40	62.9	30-95	1.1	0-5
Sugar pine	1	90.0	--	0	--	90.0	--	0	--
Total or average	15	70.7	30-100	14.0	0-40	64.7	30-95	1.0	0-5
Evans:									
Douglas-fir	14	84.6	45-100	25.4	0-60	75.0	25-100	0	--
Pine mixture	1	70.0	--	0	--	70.0	--	0	--
Total or average	15	83.7	45-100	23.7	0-60	74.7	25-100	0	--
Galice-Glendale:									
Douglas-fir	10	83.5a	60-100	22.0	0-90	79.0a	60-100	0 a	--
Sugar pine	7	65.0a	35-100	17.9	0-80	63.6a	30-95	1.4a	0-5
Total or average	17	75.9	35-100	20.3	0-90	72.6	30-100	.6	0-5
Areas combined:									
Douglas-fir	38	78.7	30-100	20.7	0-90	71.6	25-100	0.4	0-5
Sugar pine	8	68.1	35-100	15.6	0-80	66.9	30-95	1.3	0-5
Pine mixture	1	70.0	--	0	--	70.0	--	0	--
Total or average	47	76.7	30-100	19.4	0-90	70.7	25-100	.5	0-5

1/ Means followed by the same letter differ significantly--a, at 10-percent probability level; b, 5-percent; and c, 1-percent.

Stocking by Soil Series

Sample plots were sorted by soil series, and the stocking averages for the four classes of regeneration were then determined as for forest type. Sixteen soil series were represented among plots sampled in partial cuts and 14 in clearcuts (tables 8 and 9). Soil series 370 and 371 were common to all three geographic areas and to both partial cuts and clearcuts. Seven other series were common to more than one geographic area.

Total, advance, subsequent, and second-year stocking averages differed substantially among soil series in partial cuts, and a number of the differences in each stocking category proved to be statistically significant (table 8). A simple ranking of the means for data from all areas combined showed that all classes of stocking tended to be average or below on soil series 370, 371, 372, and 706. Stocking for soil series 380, 381, 701, 719, and 722 tended to be average or above except for second-year seedlings. Between pairs of means where a significant difference was demonstrated, stocking for soil series 370, 371, 372, or 718 was usually the low value for the pair and stocking for series 380, 381, 719, 721, or 781 the high value. Only two significant differences were demonstrated among stocking means for individual areas (soil series 370 vs. 741 and 371 vs. 741 for second-year stocking in the Evans area). Means for some soil series do not show a consistent relationship to each other from one locality to another nor for different stocking categories.

Table 8—Average and range of stocking by soil series in Applegate, Evans, and Galice-Glendale partial cuts

Area and soil series	Sample plots	Regeneration class 1/ All: Average	All: Range	Advance: Average	Advance: Range	Subsequent: Average	Subsequent: Range	Second-year: Average	Second-year: Range
	Number	Percent stocking							
Applegate:									
370	8	75.6	35-100	44.4	0-85	53.1	30-95	3.1	0-10
371	2	50.0	40-60	27.5	20-35	30.0	20-40	0	--
372	3	61.7	55-75	16.7	0-35	50.0	45-55	1.7	0-5
380	2	87.5	85-90	35.0	25-45	72.5	70-75	2.5	0-5
718	9	73.9	30-95	30.6	10-70	60.0	25-90	1.1	0-5
719	2	87.5	80-95	50.0	30-70	67.5	60-75	0	--
721	2	95.0	90-100	77.5	70-85	70.0	65-75	2.5	0-5
722	2	97.5	95-100	72.5	65-80	57.5	55-60	0	--
781	3	71.7	50-90	26.7	15-45	63.3	45-90	3.3	0-10
824	1	95.0	--	45.0	--	95.0	--	10.0	--
861	1	75.0	--	70.0	--	35.0	--	5.0	--
Total or average	35	76.4	30-100	40.0	0-85	58.0	20-95	2.1	0-10
Evans:									
370	4	85.0	80-90	53.8	45-70	57.5	40-75	0 a	--
371	6	75.0	55-90	54.2	10-80	40.0	15-70	$1.7a_1$	0-10
380	1	90.0	--	75.0	--	65.0	--	0	--
706	3	75.0	50-95	58.3	40-95	45.0	40-55	3.3	0-5
718	1	90.0	--	5.0	--	90.0	--	0	--
719	1	80.0	--	50.0	--	65.0	--	5.0	--
721	2	90.0	85-95	20.0	15-25	80.0	--	0	--
732	1	60.0	--	60.0	--	15.0	--	25.0	--
741	5	80.0	60-95	60.0	40-80	50.0	20-75	$8.0aa_1$	0-20
824	1	80.0	--	50.0	--	50.0	--	15.0	--
Total or average	25	79.8	50-95	51.8	5-95	52.0	15-90	4.2	0-25
Galice-Glendale:									
370	2	65.0	55-75	35.0	--	40.0	25-55	2.5	0-5
371	6	84.2	55-100	60.8	35-80	48.3	10-75	.8	0-5
372	2	72.5	45-100	65.0	35-95	42.5	15-70	0	--
380	4	90.0	65-100	58.8	35-90	65.0	35-100	0	--
381	6	95.0	85-100	71.7	20-95	61.7	25-90	8.3	0-35
701	1	95.0	--	95.0	--	75.0	--	0	--
719	2	92.5	85-100	87.5	75-100	50.0	45-55	12.5	0-25
721	3	91.7	85-100	58.3	35-75	66.7	55-80	1.7	0-5
781	1	95.0	--	85.0	--	60.0	--	35.0	--
Total or average	27	87.4	45-100	65.2	20-100	56.3	10-100	4.6	0-35
Areas combined:									
370	14	$76.8a_5a_7$	35-100	$45.7a_2$	0-85	$52.5a_2$	25-95	2.1ba	0-10
371	14	$75.4aa_3$	40-100	53.2b	10-80	$42.1cbb_1a_1$	10-75	$1.1b_2b_6a_1$	0-10
372	5	$66.0bb_1a_1a_4$	45-100	$36.0a_4$	0-95	47.0a	15-70	$1.0b_4$	0-5
380	7	$89.3a_1$	65-100	$54.3a_1$	25-90	67.1b	35-100	$.7b_5a_5$	0-5
381	6	$95.0baa_2a_5$	85-100	$71.7ca_2a_4$	20-95	$61.7a_1$	25-90	$8.3b_6aa_2a_3a_5$	0-35
701	1	95.0	--	95.0	--	75.0	--	0	--
706	3	75.0	50-95	58.3	40-95	45.0	40-55	3.3	0-5
718	10	$75.5a_2a_6$	30-95	$28.0cbb_1aa_1a_3$	5-70	$63.0b_1$	25-90	$1.0b_3a_3a_4$	0-5
719	5	$88.0a_4$	80-100	$65.0b_1$	30-100	60.0	45-75	6.0	0-25
721	7	$92.1b_1a_3a_6a_7$	85-100	52.9a	15-85	$71.4caa_2$	55-80	$1.4b_1a_2$	0-5
722	2	97.5	95-100	72.5	65-80	57.5	55-60	0	--
732	1	60.0	--	60.0	--	15.0	--	25.0	--
741	5	80.0	60-95	$60.0a_3$	40-80	50.0	20-75	$8.0a_1a_4$	0-20
781	4	77.5	50-95	41.3	15-85	62.5	45-90	$11.3bb_1b_2b_3b_4b_5$	0-35
824	2	87.5	80-95	47.5	45-50	72.5	50-95	12.5	10-15
861	1	75.0	--	70.0	--	35.0	--	5.0	--
Total or average	87	80.8	30-100	51.2	0-100	55.7	10-100	3.5	0-35

1/ Means followed by the same letter or letter plus subscript differ significantly--a, at 10-percent probability level; b, 5-percent; and c, 1-percent.

Table 9—Average and range of stocking by soil series in Applegate, Evans, and Galice-Glendale clearcuts

Area and soil series	Sample plots	All: Average	All: Range	Advance: Average	Advance: Range	Subsequent: Average	Subsequent: Range	Second-year: Average	Second-year: Range
		Regeneration class 1/							
	Number	Percent stocking							
Applegate:									
370	4	78.8a	60-95	18.8	0-35	76.3b	60-95	1.3	0-5
371	1	100.0	--	10.0	--	95.0	--	5.0	--
372	1	50.0	--	5.0	--	45.0	--	0	--
380	1	85.0	--	5.0	--	75.0	--	5.0	--
718	3	46.7a	30-60	5.0	0-15	43.3b	30-60	0	--
719	1	70.0	--	30.0	--	60.0	--	0	--
824	3	70.0	45-90	23.3	5-40	56.7	40-65	0	--
861	1	90.0	--	0	--	90.0	--	0	--
Total or average	15	70.7	30-100	14.0	0-40	64.7	30-95	1.0	0-5
Evans:									
370	1	100.0	--	30.0	--	90.0	--	0	--
371	3	88.3	80-95	20.0	0-60	78.3	60-95	0	--
712	2	87.5	85-90	30.0	--	80.0	--	0	--
719	1	70.0	--	0	--	70.0	--	0	--
721	3	90.0	70-100	35.0	15-55	80.0	45-100	0	--
722	3	80.0	70-90	23.3	10-35	71.7	50-85	0	--
731	1	45.0	--	25.0	--	25.0	--	0	--
741	1	90.0	--	5.0	--	85.0	--	0	--
Total or average	15	83.7	45-100	23.7	0-60	74.7	25-100	0	--
Galice-Glendale:									
370	2	92.5	90-95	7.5	5-10	92.5	90-95	0	--
371	11	71.8	35-100	26.8	0-90	67.7	30-95	.9	0-5
380	1	100.0	--	10.0	--	100.0	--	0	--
381	3	71.7	60-90	8.3	0-20	68.3	60-80	0	--
Total or average	17	75.9	35-100	20.3	0-90	72.6	30-100	0.6	0-5
Areas combined:									
370	7	85.7c	60-100	17.1	0-35	82.9ca$_1$	60-95	.7	0-5
371	15	77.0b$_1$	35-100	24.3	0-90	71.7b$_1$	30-95	1.0	0-5
372	1	50.0	--	5.0	--	45.0	--	0	--
380	2	92.5	85-100	7.5	5-10	87.5	75-100	2.5	0-5
381	3	71.7	60-90	8.3	0-20	68.3	60-80	0	--
712	2	87.5	85-90	30.0	--	80.0	--	0	--
718	3	46.7cbb$_1$a	30-60	5.0	0-15	43.3cbb$_1$a	30-60	0	--
719	2	70.0	--	15.0	0-30	65.0	60-70	0	--
721	3	90.0b	70-100	35.0	15-55	80.0b	45-100	0	--
722	3	80.0a	70-90	23.3	10-35	71.7a	50-85	0	--
731	1	45.0	--	25.0	--	25.0	--	0	--
741	1	90.0	--	5.0	--	85.0	--	0	--
824	3	70.0	45-90	23.3	5-40	56.7a$_1$	40-65	0	--
861	1	90.0	--	0	--	90.0	--	0	--
Total or average	47	76.7	30-100	19.4	0-90	70.7	25-100	0.5	0-5

1/ Means followed by the same letter or letter plus subscript differ significantly--a, at 10-percent probability level; b, 5-percent; and c, 1-percent.

Averages for total and subsequent stocking in clearcuts also differed substantially among soil series, and some of the differences proved to be significant (table 9). A simple ranking of the means for data from all areas combined showed that total, advance, and subsequent stocking tended to be average or below on soil series 372, 381, 718, and 719. Stocking for soil series 370, 712, 721, and 722 tended to be average or above. Stocking on soil series 372 ranked low, as in partial cuts, but position of soil series 370 was reversed; stocking on it ranked relatively high in clearcuts. Between pairs of means where a significant difference was demonstrated, stocking for soil series 718 or 824 was the low value for the pair and stocking for series 370, 371, 721, or 722 was the high value. Again, only two significant differences were demonstrated among stocking means for individual areas, soil series 718 vs. 370 for total and subsequent stocking in the Applegate area. Data were insufficient for making comparisons among stocking averages for second-year seedlings.

Most of the soil series where stocking was low are gravelly loams or gravelly clay loams, but so are several of the soils where stocking was above average.

Soil origin and soil depth were examined for their influence on seedling stocking by regrouping separately in three categories all sample plots for partial cuts and all sample plots for clearcuts. Stocking tended to be higher than average on soils of granitic origin and lower than average on soils of volcanic origin (table 10). In partial cuts, some of the differences among means proved significant.

Stocking for several regeneration classes tended to be higher on deep soils—those with a total depth 45 inches (114 cm) or greater (table 10). The differences in clearcuts between medium-depth and deep soils were statistically significant for total stocking and subsequent stocking. Surprisingly little difference in stocking was evident between shallow and medium-depth soils.

Stocking by Location

Average stocking in partial cuts and in clearcuts differed significantly by geographic location. Three ways of grouping sample plots were used to examine location effect—grouping by longitude (range), by latitude (township), and by drainage. Sample plots were grouped by township tiers because, individually, few townships would have been represented by sufficient samples for meaningful comparisons. A grouping by range was used because, from west to east, it represents increasing distances inland from the coast.

Total stocking for partial cuts averaged significantly greater in R. 8 W. and R. 9 W. than in R. 1 W., R. 2 W., R. 4 W., and R. 7 W.; total stocking was intermediate in R. 2 E., R. 3 W., R. 5 W., and R. 6 W. (table 11). Total stocking was highest nearest the coast but did not vary significantly among the more inland locations. Averages for advance stocking and subsequent stocking did not conform to the pattern shown by total stocking. Advance stocking was significantly greater in R. 5 W. and R. 8 W. than in R. 2 W., R. 3 W., and R. 4 W., and was intermediate in R. 2 E., R. 1 W., R. 6 W., R. 7 W., and R. 9 W. Subsequent stocking was highest in R. 3 W. and R. 9 W., and lowest in R. 1 W.; several stocking averages were significantly greater than the low values for R. 1 W.

Table 10—Average stocking by soil origin and soil depth in partial cuts and clearcuts

Soil characteristic	Sample plots	Regeneration class 1/ All	Advance	Subsequent	Second-year
	Number	Percent stocking			
PARTIAL CUTS					
Origin:					
Volcanic	9	76.1a	59.4	44.4b	8.3bb1
Granitic	10	91.5aa1	58.5	65.0b	1.5b
Metamorphic	68	79.9a1	49.0	55.9	3.2b1
Total or average	87	80.8	51.2	55.7	3.5
Depth:					
30 inches or less 2/	14	80.7	50.4	58.9	2.9
31-44 inches	40	79.1	49.0	53.9	4.0
45 inches or more	33	82.9	54.2	56.7	3.2
Total or average	87	80.8	51.2	55.7	3.5
CLEARCUTS					
Origin:					
Volcanic	2	67.5	15.0	55.0	0
Granitic	7	85.7	25.0	77.9	0
Metamorphic	38	75.5	18.6	70.3	.7
Total or average	47	76.7	19.4	70.7	0.5
Depth:					
30 inches or less 2/	5	73.0	27.0	62.0	0
31-44 inches	25	72.4a	19.0	66.8b	.6
45 inches or more	17	84.1a	17.6	79.1b	.6
Total or average	47	76.7	19.4	70.7	0.5

1/ Means followed by the same letter or letter plus subscript differ significantly--a, at 10-percent probability level; and b, 5-percent.

2/ To convert inches to centimeters, multiply by 2.54.

Table 11—Average stocking in partial cuts by range

Area and range	Sample plots	Regeneration class 1/ All	Advance	Subsequent	Second-year
	Number	Percent stocking			
Applegate:					
R. 2 W., T. 38, 39 S.	4	67.5a	21.3ca$_1$	52.5	0
R. 3 W., T. 37, 38, 39 S.	6	77.5	35.8b	66.7	2.5
R. 4 W., T. 37, 38, 39 S.	6	70.0a$_1$	24.2c$_1$a	60.0	1.7
R. 5 W., T. 38, 39 S.	7	91.4baa$_1$	67.9cc$_1$c$_2$b	61.4	2.9
R. 6 W., T. 38, 39 S.	5	85.0	51.0aa$_1$	61.0	3.0
R. 7 W., T. 38, 40 S.	7	65.0b	32.1c$_2$	46.4	2.1
Total or average	35	76.4	40.0	58.0	2.1
Evans:					
R. 2 E., T. 32 S.	1	85.0	60.0	40.0	0
R. 1 W., T. 32, 33 S.	4	71.3	61.3a$_2$	31.3ba	7.5a
R. 2 W., T. 32, 33 S.	5	79.0	56.0a$_1$	57.0a	12.0cb
R. 3 W., T. 33, 34, 35 S.	6	82.5	31.7aa$_1$a$_2$	66.7b	0 ca
R. 4 W., T. 33, 34, 35 S.	7	80.7	55.7a	50.0	2.1b
R. 5 W., T. 33, 34 S.	2	85.0	65.0	50.0	0.
Total or average	25	79.8	51.8	52.0	4.2
Galice-Glendale:					
R. 3 W., T. 32 S.	1	90.0	65.0	80.0	0
R. 4 W., T. 31, 32 S.	3	81.7	38.3bb$_1$a	63.3b	3.3
R. 5 W., T. 32 S.	2	77.5	55.0	57.5	2.5
R. 6 W., T. 33, 34 S.	3	76.7	71.7a	26.7bb$_1$aa$_1$	11.7
R. 7 W., T. 33, 34, 35, 36 S.	7	86.4	76.4b$_1$	53.6a$_1$	8.6
R. 8 W., T. 31, 32, 33, 34 S.	6	93.3	74.2b	55.0a	0.8
R. 9 W., T. 31, 32, 33, 35 S.	5	95.0	55.0	70.0b$_1$	2.0
Total or average	27	87.4	65.2	56.3	4.6
Areas combined:					
R. 2 E., T. 32 S.	1	85.0	60.0	40.0	0
R. 1 W., T. 32, 33 S.	4	71.3a$_3$a$_7$	61.3	31.3cbaa$_2$a$_4$	7.5
R. 2 W., T. 32, 33, 38, 39 S.	9	73.9a$_2$a$_6$	40.6ba$_2$	55.0a	6.7
R. 3 W., T. 32, 33, 34, 35, 37, 38, 39 S.	13	80.8	36.2cb$_3$aa$_1$	67.7ca$_1$a$_3$	1.2
R. 4 W., T. 31, 32, 33, 34, 35, 37, 38, 39 S.	16	76.9aa$_4$	40.6b$_1$b$_2$	56.3a$_2$	2.2
R. 5 W., T. 32, 33, 34, 38, 39 S.	11	87.7	65.0b$_2$b$_3$a$_2$	58.6a$_4$	2.3
R. 6 W., T. 33, 34, 38, 39 S.	8	81.9	58.8a$_1$	48.1a$_3$	6.3
R. 7 W., T. 33, 34, 35, 36, 38, 40 S.	14	75.7a$_1$a$_5$	54.3a	50.0a$_1$	5.4
R. 8 W., T. 31, 32, 33, 34 S.	6	93.3aa$_1$a$_2$a$_3$	74.2cbb$_1$	55.0	0.8
R. 9 W., T. 31, 32, 33, 35 S.	5	95.0a$_4$a$_5$a$_6$a$_7$	55.0	70.0b	2.0
Total or average	87	80.8	51.2	55.7	3.5

1/ Means followed by the same letter or letter plus subscript differ significantly--a, at 10-percent probability level; b, 5-percent; and c, 1-percent.

Significant differences among stocking averages were also demonstrated within individual geographic areas. In Applegate, total stocking was significantly higher in R. 5 W. than in R. 2 W., R. 4 W., and R. 7 W. Advance stocking was significantly higher in R. 5 W. than in R. 2 W., R. 3 W., R. 4 W., and R. 7 W., but subsequent stocking did not differ significantly among the ranges represented. Averages for total stocking did not differ significantly in the Evans area, but advance stocking was significantly lower in R. 3 W. than elsewhere, and subsequent stocking was significantly higher in R. 2 W. and R. 3 W. than in R. 1 W. In the Galice-Glendale area, averages for total stocking also did not differ significantly but averages for advance and subsequent stocking did. Advance stocking was significantly lower in R. 4 W. than in R. 6 W., R. 7 W., and R. 8 W., and subsequent stocking was significantly lower in R. 6 W. than in most of the others. Subsequent stocking in Galice-Glendale was highest in R. 3 W. and R. 9 W.

Stocking tended to be more uniform in clearcuts, as indicated by the small number of significant differences among averages representing the different ranges (table 12). Total, advance, and subsequent stocking were highest in R. 9 W.; total and subsequent stocking in R. 9 W. were significantly greater than for R. 8 W., which is immediately adjacent to the east. The same differences appear in averages for Galice-Glendale because this area is the sole source of data for R. 8 W. and R. 9 W. Other significant differences appear to be incidental rather than indicators of any meaningful pattern.

Although significant differences in stocking were found between tiers of townships, no north-south trend was evident in either partial cuts or clearcuts (table 13). Total and advance stocking in partial cuts averaged highest in T. 34 S. and lowest in T. 38 S. In clearcuts, total stocking was again low in T. 38 S., but just as low in T. 34 S., and highest in T. 32 S. and T. 35 S. Subsequent stocking was also lowest in T. 34 S. and T. 38 S. and highest in T. 32 S. and T. 35 S. The differences in stocking among tiers of townships appear to be caused by local factors more than by any effect of latitude.

Stocking differed significantly among stream drainages (table 14). Partial cuts sampled in small drainages that flow directly to the middle section of the Rogue River had the highest total, advance, and subsequent stocking. Williams Creek, Evans Creek, West Cow Creek, and Applegate River were other drainages where stocking was above average for one or more regeneration classes. Subsequent stocking in partial cuts was clearly below average in Bear Creek, Illinois River, Elk Creek, Trail Creek, and Grave Creek.

In clearcuts, stocking tended to be more uniform among drainages. Highest stocking (but not significantly greater than for several other drainages) was found in West Cow Creek, which drains eastward from the Coast Ranges in contrast to all other drainages sampled. Total and subsequent stocking were significantly lower in Applegate River clearcuts than in any other drainage.

Table 12—Average stocking in clearcuts by range

Area and range	Sample plots	Regeneration class 1/ All	Advance	Subsequent	Second-year
	Number	- - - - - - - - - -Percent stocking- - - - - - -			
Applegate:					
R. 2 W., T. 38 S.	1	50.0	15.0	40.0	0
R. 3 W., T. 38, 39 S.	3	53.3	10.0	50.0	0 a
R. 5 W., T. 38, 39 S.	2	75.0	0	75.0	0
R. 6 W., T. 38, 39 S.	6	77.5	24.2a	69.2	.8
R. 7 W., T. 38, 39, 40 S.	3	78.3	6.7a	71.7	3.3a
Total or average	15	70.7	14.0	64.7	1.0
Evans:					
R. 1 E., T. 33 S.	1	45.0	25.0	25.0	0
R. 1 W., T. 32 S.	1	90.0	5.0	85.0	0
R. 3 W., T. 33, 34 S.	7	84.3	32.1b	72.1	0
R. 4 W., T. 33 S.	3	85.0	3.3ba	85.0	0
R. 5 W., T. 33, 35 S.	3	91.7	30.0a	83.3	0
Total or average	15	83.7	23.7	74.7	0
Galice-Glendale:					
R. 3 W., T. 31 S.	1	60.0	10.0	60.0	0
R. 4 W., T. 31, 32 S.	2	80.0	2.5	80.0	0
R. 7 W., T. 34 S.	1	60.0	5.0	60.0	0
R. 8 W., T. 31, 32, 34, 35 S.	9	70.6a	21.7	66.7a	1.1
R. 9 W., T. 31, 32, 34 S.	4	93.8a	32.5	88.8a	0
Total or average	17	75.9	20.3	72.6	.6
Areas combined:					
R. 1 E., T. 33 S.	1	45.0	25.0	25.0	0
R. 1 W., T. 32 S.	1	90.0	5.0	85.0	0
R. 2 W., T. 38 S.	1	50.0	15.0	40.0	0
R. 3 W., T. 31, 33, 34, 38, 39 S.	11	73.6	24.1	65.0a	0 b
R. 4 W., T. 31, 32, 33 S.	5	83.0	3.0a	83.0	0 b_1
R. 5 W., T. 33, 35, 38, 39 S.	5	85.0	18.0	80.0	0 b_2
R. 6 W., T. 38, 39 S.	6	77.5	24.2	69.2	.8
R. 7 W., T. 34, 38, 39, 40 S.	4	73.8	6.3	68.8	2.5$bb_1b_2b_3$
R. 8 W., T. 31, 32, 34, 35 S.	9	70.6a	21.7	66.7a_1	1.1
R. 9 W., T. 31, 32, 34 S.	4	93.8a	32.5a	88.8aa_1	0 b_3
Total or average	47	76.7	19.4	70.7	.5

1/ Means followed by the same letter or letter plus subscript differ significantly--a, at 10-percent probability level; and b, 5-percent.

Table 13—Average stocking by township tier in partial cuts and clearcuts

Township tier	Sample plots	Regeneration class 1/			
		All	Advance	Subsequent	Second-year
	Number	Percent stocking			
		PARTIAL CUTS			
31	4	83.8	51.3	50.0	2.5
32	11	81.8	55.0	50.5	5.0
33	18	81.1	56.7a	53.3	2.5
34	13	88.1b	66.9cb	58.1	3.8
35	5	84.0	54.0	58.0	7.0
36	1	95.0	85.0	60.0	35.0
37	3	81.7	48.3	71.7	1.7
38	16	71.6b	37.2ca	52.2	2.8
39	14	79.3	42.1b	59.6	1.4
40	2	87.5	35.0	72.5	2.5
Total or average	87	80.8	51.2	55.7	3.5
		CLEARCUTS			
31	4	77.5	37.5 $b_3 a a_1$	68.8	0
32	5	93.0$b b_3 a$	10.0ba	90.0$b b_1 a$	0
33	11	83.6$b_2 a_2$	26.4a_2	73.2	0
34	9	63.9$b b_1 b_2$	7.8$c b_3 a_2$	63.3b_1	1.1
35	3	91.7$b_1 a_1$	46.7$c b b_1 b_2$	85.0	0.
38	6	65.0$b_3 a_1 a_2$	17.5b_2	59.2b	.8
39	8	73.1a	12.5$b_1 a_1$	67.5a	.6
40	1	85.0	5.0	75.0	5.0
Total or average	47	76.7	19.4	70.7	.5

1/ Means followed by the same letter or letter plus subscript differ significantly--a, at 10-percent probability level; b, 5-percent; and c, 1-percent.

Table 14—Average stocking by drainage in partial cuts and clearcuts

Drainage	Sample plots	Regeneration class 1/			
		All	Advance	Subsequent	Second-year
	Number	Percent stocking			
PARTIAL CUTS					
Bear Creek	2	50.0	20.0	35.0	0
Applegate River	12	$75.4c_1a_3$	$25.4cc_3c_4b_1b_2b_3aa_1$	$65.0c_2c_4a_3$	2.5
Williams Creek	11	$88.2b_3a_3$	$62.3c_3b_4$	$58.2b_1b_2$	2.3
Illinois River	8	$67.5cb_2b_3a$	$32.5c_1b_4b_5a_2$	$48.8b_3aa_3$	1.9
Middle Rogue	13	$94.2cc_1bb_1a_1a_2$	$75.8cc_1c_2b$	$68.1cc_1b_3a_1a_2$	5.8
Elk Creek	3	$71.7a_1$	56.7a	$25.0cc_2c_3bb_1a$	10.0
Trail Creek	4	71.3b	$53.8b_2$	$46.3a_1$	2.5
Evans Creek	14	$82.9aa_2$	$46.8c_2b_3$	$63.2c_3c_6$	4.6
Grave Creek	9	$76.7b_1$	$61.1c_4b_5$	$34.4c_1c_4c_5c_6b_2$	3.9
East Cow Creek	6	81.7	$48.3ba_1$	$64.2c_5b$	2.5
West Cow Creek	5	$90.0b_2$	$60.0b_1a_2$	$49.0a_2$	1.0
Total or average	87	80.8	51.2	55.7	3.5
CLEARCUTS					
Applegate River	4	$52.5cc_1baa_1$	11.3	$47.5bb_1b_2aa_1a_2$	0 a
Williams Creek	3	81.7a	6.7	$81.7b_1$	0 a_2
Illinois River	8	75.6b	18.1	$66.9a_1$	$1.9baa_1a_2$
Middle Rogue	10	$72.0a_1a_2$	20.5	$69.5a_2$	1.0
Elk Creek	2	67.5	15.0	55.0	0
Evans Creek	10	$84.5c_1$	23.5	$76.0b_2$	0 b
Grave Creek	2	80.0	17.5	75.0	0
East Cow Creek	3	73.3	5.0a	73.3a	0
West Cow Creek	5	$93.0ca_2$	36.0a	84.0b	0 a_1
Total or average	47	76.7	19.4	70.7	.5

1/ Means followed by the same letter or letter plus subscript differ significantly--a, at 10-percent probability level; b, 5-percent; and c, 1-percent.

Tests for Associations

Data on 15 environmental variables were used in both correlation and regression analyses to ascertain stocking patterns in partial cuts. The independent variables or covariates are listed below; data source and pertinent details on most are given in the appendix (p. 70):

1. Elevation (feet)
2. Average annual precipitation (inches)
3. Aspect index
4. Average slope (percent)
5. Radiation index
6. Canopy (percent)
7. Time since logging (years)
8. Total ground cover (percent)
9. Ground cover primarily grass (percent)
10. Ground cover primarily woody perennials (percent)

11. Seedbed primarily duff and litter (percent)

12. Seedbed primarily logs, wood, and bark (percent)

13. Seedbed primarily undisturbed, variables 11 and 12 combined (percent)

14. Nearest seed source, Douglas-fir (percent)

15. Nearest seed source, true firs (percent)

Thirteen variables were used for analyses of stocking patterns in clearcuts. Distance to seed source was substituted for variables 14 and 15, above, which give seed source proximity for only two individual species. Although some canopy was present on clearcuts, variable 6 was deleted because it represented a severe mix of independent and dependent variables—residual trees plus high brush and regeneration that developed after logging.

Variables 9 to 15 resulted from classifying the 20 subplots per plot in different ways. For example, variables 9 and 10 are fractions (each expressed as a percentage of 20) of a four-way classification—without cover, grass cover, herbaceous cover, or woody perennial cover. Not all parts of such a classification may be validly included in a regression analysis. The specific fractions selected were those that appeared most likely to differ from the rest, had the widest range of data, or were of particular interest.

Sufficiently comprehensive regeneration data were available from Applegate, Evans, and Galice-Glendale partial cuts and clearcuts for these dependent variables:

1. Total stocking

2. Advance stocking, all species

3. Advance stocking, Douglas-fir

4. Advance stocking, true firs

5. Advance stocking, incense-cedar

6. Subsequent stocking, all species

7. Subsequent stocking, Douglas-fir

8. Subsequent stocking, true firs

9. Subsequent stocking, incense-cedar

10. Second-year stocking, all species

Subsequent stocking of sugar and western white pine was used as an additional dependent variable for partial cuts, and subsequent ponderosa pine stocking for clearcuts. For neither pine group were data sufficient in both partial cuts and clearcuts.

Correlation tests between single independent and dependent variables indicated that in the Applegate, Evans, and Galice-Glendale areas stocking level changes in concert with other variables. There are variations or patterns of stocking significantly associated with changes in independent environmental variables, such as elevation, radiation index, slope, and precipitation; and covariates, such as total ground cover, grass, and woody perennials. Correlations identified as significant for different categories of regeneration in the three areas are listed in appendix tables 25 to 30; only highlights are discussed here.

Relatively few significant correlations were found between total stocking and environmental variables when data sets for the three areas were combined. In partial cuts, total stocking increased as years since harvest and amount of precipitation increased. Total stocking decreased as slope, amount of Douglas-fir seed source, and the amount of seedbed covered with logs, wood, and bark increased (table 25, appendix). When data sets were combined for all clearcuts, total stocking correlated with just one variable; it correlated positively with nearness of seed source (table 27, appendix).

These broad associations did not prevail consistently, however, in the individual areas. For example, total stocking was correlated with slope, years since harvest, and amount of Douglas-fir seed source in Applegate partial cuts, but these did not appear as significant factors in Evans or Galice-Glendale partial cuts. In fact, not one of the five factors significant for the combined data set was significant in the data set for more than a single area. For clearcuts, precipitation was a significant factor common to the Applegate and Evans areas.

For the areas combined, total subsequent stocking in partial cuts decreased as the percentage of undisturbed seedbed or duff and litter increased (table 26, appendix). Total subsequent stocking did not correlate significantly with a single environmental variable when data sets for clearcuts were combined (table 28, appendix).

As with total stocking, correlations between total subsequent stocking and environmental variables varied by area. In partial cuts, total subsequent stocking was positively associated with elevation and negatively associated in one or more areas with those factors that tend to keep seedbed unavailable—undisturbed seedbed, duff and litter, and logs, wood, and bark. For clearcuts within individual areas, total subsequent stocking was positively associated with precipitation and negatively associated with radiation index; logs, wood, and bark; and undisturbed seedbed (fig. 16).

The sets of environmental variables that advance or subsequent stocking of individual species correlated with differed substantially. Diverse species responses to environmental factors are probably indicated by some correlations. For example, subsequent stocking of Douglas-fir was positively associated with woody perennials in Galice-Glendale clearcuts ($r = 0.50$), but subsequent stocking of ponderosa pine was negatively associated with woody perennials ($r = -0.90$). Not unexpectedly, stocking of a species sometimes correlated either positively or negatively with a given variable, depending on differing circumstances. For example, stocking of Douglas-fir advance growth in partial cuts was positively correlated with undisturbed seedbed, but stocking of subsequent Douglas-fir was negatively correlated with the same variable. These opposite results for the same species are entirely reasonable because the continued existence of advance growth depends on lack of

Figure 16.—Total subsequent stocking in both partial cuts and clearcuts tended to be greater with higher percentages of disturbed seedbed.

disturbance during logging whereas establishment of subsequent regeneration hinges on the ready availability of seedbed.

Stocking had a reasonably consistent correlation with several environmental variables in both partial cuts and clearcuts. For example, stocking usually decreased as slope increased; as amount of seedbed covered with logs, wood, and bark increased; and as the cover of woody perennials increased. Higher stocking was generally but not always associated with greater precipitation. Stocking tended to be greater in older partial cuts, but stocking was negatively correlated with the age of clearcuts. In a similar contrast, stocking was positively correlated with radiation index in partial cuts, but negatively correlated with radiation index in clearcuts. In other words, stocking was higher on slopes most exposed to the sun in partial cuts and on slopes least exposed to the sun in clearcuts. Another stocking contrast between partial cuts and clearcuts is in correlations for seed source: in partial cuts, stocking was generally negatively correlated with an increase in Douglas-fir seed source and positively correlated with an increase in true fir seed source; in clearcuts, stocking increased with closer proximity to seed source. The stocking pattern is more complex in partial cuts where it involves relative establishment and survival capabilities of different species in openings and in shade. It is also not surprising that few variables show a consistent correlation with both advance and subsequent stocking because the conditions favoring the two kinds of stocking are not identical.

Correlation coefficients between stocking and environmental variables were also determined after data had been regrouped by forest type. Because forest types are identifiable ecologic units that often span several geographic areas, there may be more consistent stocking patterns within a forest type than among the mix of types in a geographic area. Tables 29 and 30 (appendix) list stocking-environmental correlations that tested significant in each forest type. Data from three pine types—sugar pine, ponderosa pine, and pine mixture—were combined for this purpose as each type was lightly represented.

As composite averages, correlation coefficients for stocking-environmental associations in partial cuts and clearcuts were somewhat higher if data were analyzed by forest type rather than by geographic areas combined (tables 29 and 30 vs. tables 25-26 and 27-28, appendix). Average r-value for geographic areas combined was 0.30 in partial cuts, 0.31 in clearcuts; 0.34 and 0.36, respectively, for the Douglas-fir type, and 0.51 and 0.68 for the pine type. The correlation coefficients for the Douglas-fir type are not, however, as high as are the correlation coefficients derived for individual geographic areas (average $r = 0.40$ to 0.44 for partial cuts, 0.50 to 0.58 for clearcuts). Those for the pine type in clearcuts are higher than for individual geographic areas, but this may be caused partly by the limited number of samples in the type. Forest type has merit as a means of stratifying forest lands in the territory sampled, but consideration of environmental factors area by area seems even better.

Regeneration patterns in partial cuts differed among forest types as indicated by the dissimilar number and array of correlations found significant per type (tables 29 and 30, appendix). Stocking of advance regeneration was strongly associated with many enviromental variables in the Douglas-fir type and with only about one-third as many in the pine type. Though still dissimiliar, the number of significant associations for subsequent regeneration were nearly equal for the two forest types.

Several stocking-environmental associations in partial cuts were common to more than one regeneration category or forest type. Understandably, stocking of advance regeneration increased with increases in undisturbed seedbed, duff and litter, and with canopy conditions requisite to or arising from the presence of advance regeneration. Advance stocking vacillated relative to true fir seed source but decreased as the amount of Douglas-fir seed source increased. Stocking of advance Douglas-fir was positively correlated with increases in precipitation, but stocking of advance incense-cedar was negatively correlated with precipitation. Stocking of subsequent regeneration generally increased with elevation and radiation index and decreased with increases in duff and litter and with undisturbed seedbed.

For clearcuts, the number of significant stocking-environmental variable associations was not as dissimilar among forest types as in partial cuts. Nearly half of the environmental variables (16 of 34) accounted individually for 25 percent or more of the variation for different categories of advance or subsequent stocking. Correlations between stocking and an environmental variable were consistently positive or negative in only a few instances.

Formulas Describing Stocking

Correlation coefficients provide insight and identify associations between independent and dependent variables, but information is also needed on how stocking interacts in concert with several independent variables. For this purpose, stepwise multiple regression analyses were made with data for the environmental variables and regeneration categories already itemized (p. 40-41). Analyses were made with single and combined data sets for Applegate, Evans, and Galice-Glendale partial cuts, and for Applegate, Evans, and Galice-Glendale clearcuts. Independent variables listed in each formula are generally those that singly had an F-value (variance ratio) to enter or remove from the equation equal to or greater than the critical value of the F-distribution at $p = 0.10$. Occasionally, a variable with a smaller F-value was included because of its position within the array of qualifying variables, its contribution to the cumulative R^2 (coefficient of determination), or its effect on minimizing residual variation (provided the total number of variables remained reasonable for the size of the data base).

The analyses produced statistically significant multiple regression formulas that, for each of the 11 regeneration categories, relate the variation of stocking to changes in one or more environmental variables. Formulas for partial cuts in individual areas are listed in tables 31-33 (appendix) and for clearcuts in tables 35-37 (appendix). Nearly two-thirds (20 of 33) of the regressions for partial cuts are strongly descriptive—with three to seven variables, they individually account for 52 to 87 percent of the variation (cumulative R^2) in stocking. None account for less than 25 percent of the total variation. Collectively, the regressions for Applegate data account for less of the total variation in stocking than do those for Evans and Galice-Glendale. It appears that either random variation was greater or unmeasured variables are influencing stocking more in Applegate than in Evans or Galice-Glendale; substantially more samples were taken in Applegate than in the other two areas (35 vs. 25 and 27).

Combining data from Applegate, Evans, and Galice-Glendale partial cuts did not produce better regressions. To the contrary, the amount of variation accounted for by every formula based on combined data was lower than the least amount of variation accounted for by the equivalent formula based on data for individual areas (tables 31-33 vs. table 34, appendix). Clearly, stocking does not vary with environmental variables in the same way in the three areas. In fact, only one-third of the variables in formulas for combined data are in common with variables in formulas for even two of the three individual areas.

Three-fourths of the regressions for clearcuts are strongly descriptive: with one to six variables, they individually account for 50 to 93 percent of the variation in stocking. Collectively, regressions for Applegate data account for more of the total variation in stocking than those for Evans or Galice-Glendale, which averaged lowest. The formulas for Galice-Glendale are based on two more samples than in the other two areas (17 vs. 15). As with partial cuts, combining data from Applegate, Evans, and Galice-Glendale clearcuts did not produce better regressions. Not a single formula based on the combined data accounted for 50 percent of the total variation; for several, the amount accounted for was so low that the formula is not meaningful (table 38, appendix). In all but two instances, the variation accounted for was less than the least amount of variation accounted for by the equivalent formula for individual areas (tables 35-37 vs. table 38, appendix). Again, about one-third of the variables in formulas for combined data are in common with variables

in formulas for even two of the three individual areas. As with partial cuts, stocking in clearcuts did not vary with environmental variables in the same way in the three areas.

A comparison of fit between sets of regression equations that describe stocking-environmental relationships in partial cuts grouped by forest type or by geographic area shows mixed results. Quality of fit was judged by summing R^2 values for sets of equations and comparing the average variation accounted for per equation.[4]

On the average, equations based on geographic area accounted for 46, 59, 55, and 30 percent of the variation in stocking for data from, respectively, Applegate, Evans, Galice-Glendale, and all areas combined (tables 31-34, appendix). Equations for the Douglas-fir type accounted for 34 percent of the stocking variation, and those for the pine type for 72 percent (tables 39 and 40, appendix). Equations based on forest type would be a better choice than equations based on combined geographic areas. Use of equations specific to individual areas would be best, especially if stocking in the Douglas-fir type were the primary concern.

For clearcuts, use of regression equations based on data for an individual geographic area is clearly preferable to those based on data for forest type. On the average, equations based on geographic area accounted for 72, 67, 55, and 33 percent of the variation in stocking for data from, respectively, Applegate, Evans, Galice-Glendale, and all areas combined (tables 35-38, appendix). Equations for the Douglas-fir type accounted for 34 percent of the stocking variation, and those for the pine type for 67 percent (tables 41 and 42, appendix).

Predicting Regeneration

Preceding sections of this report have shown how present stocking associates with or changes with observed environmental variables. But such variables as total ground cover, woody perennials, and grass are covariates. They may be absent or be of minor consequence at harvest and increase just as tree stocking does with time. To assess reforestation possibilities before an area is cut, it would be useful to know how prevailing environmental variables, plus those whose levels are regulated by the harvest, influence subsequent regeneration. For this purpose, prediction equations were developed for subsequent stocking based on environmental variables that can be observed or specified before harvest. Eleven variables—elevation, radiation index, aspect index, slope, canopy, duff and litter, logs and wood and bark, Douglas-fir seed source, true fir seed source, precipitation, and undisturbed seedbed—were used in analyses for partial cuts. Nine variables were used in analyses for clearcuts; canopy, Douglas-fir seed source, and true fir seed source were deleted from the preceding group, and seed source distance was added.

Similar prediction equations are not needed for advance regeneration because the amount present at harvest or immediately after can and should be measured directly.

The most useful equations for predicting subsequent stocking are those based on stocking data grouped by individual area. On the average, equations based on data

[4] Precise comparison of R^2 values is not possible because equations representing forest types have a broader base than those for the individual geographic area.

for the Douglas-fir type (tables 43 and 44, appendix) and on combined data for all three geographic areas (tables 45 and 46, appendix) account for little of the total variation in stocking—only 18 to 28 percent. In contrast, the average amount of variation accounted for by equations based on data for an individual area ranges from 31 to 63 percent. If pine areas were of primary interest, use of equations based on data for the pine types would be advised as those equations account for 62 to 78 percent of the total variation in stocking.

Equations based on the pine type might have broader applicability than those based on an individual geographic area because the origin of a forest type and its perpetuation seem directly related to the mix of environmental conditions that prevail. Hence, stocking-environmental relationships found important in one part of a type could reasonably be expected to prevail throughout the type.

Area-specific equations for clearcuts are substantially better than their counterparts for partial cuts—more of the total variation in stocking is accounted for based on comparisons of R^2 averages (31 to 50 vs. 45 to 63 percent). In both partial cuts and clearcuts, the lowest average R^2 values were those for the Galice-Glendale area; the highest were for Evans partial cuts and Applegate clearcuts. Most formulas account for enough variation to be a reasonable predictive tool, but some for partial cuts are not likely to prove useful. Most equations require data on only two to four environmental variables.

Forest Management Applications

A comprehensive analysis of reforestation status and relationships provides first approximations for management and serves to clarify or pinpoint problems that need to be solved. The broad implications of study results are emphasized in these interpretations; mention of how results relate to reforestation principles observed elsewhere are mostly incidental.

Silvicultural Units

The Applegate, Evans, and Galice-Glendale areas differ to various degrees in their geography, climate, forest communities, and reforestation environments. The contrasts are not as great among these areas as they are between the Dead Indian and Butte Falls areas (Stein 1981). But the stocking differences revealed in grouping data by location and the dissimilarities among areas in correlations and regressions found to relate significantly to stocking indicate that the areas are different with respect to reforestation. Variation in stocking among localities may reflect more than the effects of intrinsic environmental differences—there are differences, too, in historical uses, proximity to population centers, harvesting practices, fire history, and reforestation efforts. These can also influence regeneration results. Evaluation of the effects of all such factors was beyond the scope of this survey.

Because of the differences among geographic areas, silvicultural practices need to be applied more flexibly than they have been in the past. The variability of environmental conditions and regeneration responses found within geographic areas should also be given greater attention. Each area contains a range of sites from dry, sparsely forested inland valleys to moist, densely forested uplands. The elevation span in Applegate, in particular, ranges from dry lowlands to conditions associated with upper slope forests. That varied conditions within individual geographic areas affect regeneration response is borne out by significant correlations and regressions and by demonstrated differences in stocking averages among soil

depths, among ranges, and among adjacent stream drainages. The contrast between medium stocking of clearcuts in the Applegate River drainage and high stocking of clearcuts in nearby Williams Creek is probably the most extreme, but limited, example.

Though stocking in the cuttings sampled was generally quite good, there are opportunities to achieve even better results. A careful demarcation of lands where the same silvicultural practices appear appropriate would be a good starting point. The boundaries for geographic areas, as drawn by the District and roughly followed in this survey, encompass a wide range of site and stand conditions. These boundaries are convenient administratively, but they blur rather than delineate conditions and variations that are important silviculturally.

Forest type and soil series are existing delineations that are associated with differences in regeneration response. There are differences between regeneration present in the pine types and in the Douglas-fir type. But the Douglas-fir type, in particular, encompasses too wide a range of conditions to be treated silviculturally as a homogeneous entity. Delineating sites on the basis of soil series probably represents too much fragmentation for efficient management, but grouping sites that occur on similar soil series or grouping them by such broad soil classes as of volcanic, granitic, and metamorphic origin may prove useful. The influence of soil depth on regeneration level seems confounded or overridden by other factors as little difference in stocking was found on soils of shallow and medium depth. This is precisely where one would expect the greatest differences, rather than between medium and deep soils.

Subdivision of forest types into more discrete vegetative communities is probably necessary for intensive application of silvicultural and reforestation practices. There are, fortunately, some logical delineations already apparent that can be used now before maps showing habitat types or similar vegetative delineations become available and long before such units are calibrated in terms of regeneration response. Some obvious ones include:

1. Upper slope forests recognizable primarily on the basis of elevation and the increasing prominence of true firs. Results of regeneration studies in the Dead Indian area and in other upper slope stands are probably applicable at upper elevations in the western part of the District, particularly in the Applegate area.

2. Valley bottoms and foothills where cold air drainage magnifies frost problems, hardwoods and chaparral compete vigorously with conifers, and summer moisture is marginal. A geologic and floristic perspective on the current and former extent of chaparral in southwestern Oregon is given by Detling (1961). Some of the data on vegetation patterns developed by Whittaker (1954, 1960) pertain to foothill stands; much of his data bear directly on conditions in the western part of the Applegate area.

3. Serpentine areas have unique, often sparse, plant communities (Whittaker and others 1954). Such sites are readily identifiable and require special evaluation to determine their suitability for and level of timber management.

4. Eastern and western Siskiyous have notably different vegetation complexes (Waring 1969). Waring's delineation bisects the Applegate area from west of Grants Pass diagonally southeastward. The information developed on forest environments and vegetative communities in the eastern Siskiyous should prove very useful.

5. Port-Orford-cedar occurrence may also provide a basis for broad delineation of vegetation in western parts of the Applegate and Galice-Glendale areas. There are noticeable differences in environmental conditions where this species does or does not occur. Absence of Port-Orford-cedar and several other tree species were included in criteria for delineating eastern and western Siskiyous (Waring 1969).

Regeneration practices can be improved by heeding the environmental clues implied by the above vegetational delineations and by others that can be readily identified through careful and systematic observations. Contemporary examples of efforts to relate regeneration responses to environmental factors, area by area, are those for a core Applegate area (Minore and others 1982), for Hungry-Pickett (Graham and others 1982), and for Illinois Valley (Minore and others 1984). As regeneration experiences accumulate in such delineated subdivisions, refinements can be made in reforestation practices.

Interpreting Stocking Data

Stocking values generally express actual stocking as a percentage of full stocking. Consequently, full stocking must be defined before the true significance of observed stocking values can be assessed. By agreement among participants at the start of this study, full stocking was set at 250 uniformly distributed trees per acre (618 per ha). This standard can be met if one countable tree is present on every 4-milacre (0.00162-ha) subplot examined.

In the stocked quadrat sampling system, only one countable tree must be present for a 4-milacre plot to be stocked (Stein 1978, 1984). Hence, a stocking value of 50 percent means that at least 125 well-distributed trees are present per acre (310 per ha). The system produces a minimum figure; it is strongly oriented toward evaluation of tree distribution, not total numbers. Where trees are uniformly distributed as in a plantation, stocking may closely reflect the total number present. Not so for natural regeneration or mixes of artificial and natural regeneration. In natural regeneration, 50-percent stocking might mean nearly 400 trees per acre (990 per ha) and 85-percent stocking over 1,200 trees per acre (2 965 per ha) (Bever and Lavender 1955). The conversion curve used in this example was developed from data for natural regeneration in clearcuts of western Oregon and may not be fully applicable in partial cuts. The comparisons indicate, however, what stocking data mean in terms of total trees per acre.

If stocked and nonstocked plots are well interspersed, 50-percent stocking can produce a good stand; if they are not, part of the sampled area will be well stocked or overstocked and part of the area will be short of trees.

Regeneration in Partial Cuts

Throughout this paper, forest stands from which some overstory had been removed through harvest have been called partial cuts, not shelterwoods. This was done deliberately because many partially cut stands did not qualify as shelterwoods in the full technical sense of that term. Instead, they were the product of an initial cut in virgin old-growth forest of varied composition, density, age class, and size. Many stands had had an open overstory for a long time before harvest, which fostered advance regeneration. Some stands were cluttered with overly dense advance regeneration; others with a more uniform and heavy canopy were relatively bare underneath. Thus, stocking data reflect the regeneration present in a wide range of postharvest stand conditions rather than in uniform stands whose nature can be defined readily.

The partial cutting done in the Medford District between 1956 and 1971 when the stands sampled in this survey were created has been referred to as a "three-stage shelterwood." A first cut to open up the stand was to be followed by a second cut in 10 years and a final cut in another 10 years. The second cut was intended to foster regeneration. According to the records, only one of the stands sampled had received a second cut (in Applegate). This stand was well stocked and data from it were included in all summaries.

Achievement of a specified basal area, composition, or distribution of overstory did not appear to have been among primary objectives for the first cut. In some stands, scattered single trees had been removed, leaving a reasonably uniform and rather dense overstory; in others, small clearings were interspersed with nearly unthinned canopy. Some stands were opened up drastically; nine of those sampled had 30-percent canopy or less (minimum, 19 percent). Seven of these stands were well stocked; two were moderately stocked. A good choice of seed trees was readily evident in some partial cuts; in others, the adequacy of the remaining seed source was much in doubt. In summary, the partial cuts sampled had a large amount of variability before cutting, they were not necessarily made more uniform by the first cut, and all but one were sampled before the second or "regeneration" cut had been made.

Even though sampling occurred before the "regeneration" cut, substantial regeneration was found in partial cuts. In fact, 82 of the 87 plots examined in Applegate, Evans, and Galice-Glendale partial cuts had 50-percent total stocking or more, all of natural origin. Four of the five plots with less than 50-percent stocking were in Applegate; the other one was in Galice-Glendale. Characteristics of these plots included: a range in average canopy from 37 to 51 percent; in elevation from 2,330 to 3,350 feet (710 to 1 021 m); in aspect from northwest to east; in slope from 38 to 64 percent; and in time since harvest from 2 to 8 years. The oldest plot had the least stocking—30 percent. In most partial cuts, the regeneration already present could be rated as satisfactory if stocking—the presence of live trees—were the sole criterion. The situation is not that clear, however.

The vigor and growth of advance and subsequent stocking need improvement in many partial cuts. Field notes for nearly half of all partial cut plots contain comments on the lack of vigor or growth of advance or subsequent seedlings or of both. An accompanying observation was also made over and over again—that occurrence and growth of subsequent regeneration were far better on disturbed seedbeds than on undisturbed seedbeds. Excerpts from the field notes serve to emphasize these common observations on seedling occurrence and growth:

1. The majority of stocking is advance growth of very poor vigor. Some 10-year-old seedlings are under 1 foot (0.3 m) in height. With a few exceptions, logging did not release advance stocking because of the hardwood understory (Applegate area).

2. Most stocking is vigorous but some is suppressed by brush and hardwoods (Applegate area).

3. Although total stocking is 100 percent, most is advance stocking of generally poor vigor and quality. What subsequent stocking there is is also of poor vigor; the only good seedlings were in the skid roads (Applegate area).

4. None of the stocking seems to be growing vigorously. Some ponderosa pine seedlings are also present but not in the quantities you would expect considering the availability of seed (Evans area).

5. Stocking is moderate with some large holes—most gaps are on mineral soil with a heavy cover of *Ceanothus integerrimus*. Vigor of seedlings varies; the best growth occurs on disturbed sites with fairly open canopy (Evans area).

6. Heavy advance stocking, most with moderate vigor, some with poor vigor. Most subsequent stocking is in disturbed sites; subsequent stocking on undisturbed sites is generally of poor vigor (Galice-Glendale area).

7. Seedlings mainly on skid roads (Galice-Glendale area).

Overly dense stocking of advance regeneration, dense residual overstory, suppression from overtopping brush and hardwoods, and heavy vegetative competition were some of the factors commonly associated with low vigor and slow growth of regeneration. These factors must be modified before acceptable seedling development can occur in many partial cuts.

Role of Advance Regeneration

Advance regeneration was abundant in the Applegate, Evans, and Galice-Glendale partial cuts. Stocking of advance regeneration in the three areas averaged 51 percent (table 15, appendix), and advance regeneration dominated 59 percent of all stocked subplots. Immediately after the initial cut, 47 of the 87 partial cuts sampled (54 percent of the area represented) were at least 50-percent stocked with advance regeneration alone; 37 percent were at least 70-percent stocked (table 17, appendix). Before the initial cut, an even greater percentage of the partial cut acreage probably had 50-percent stocking or greater of advance regeneration. Efforts to save advance regeneration were evident in some partial cuts, but in many there was no evidence that felling or skidding practices had been modified for that purpose. Furthermore, the pattern of overstory removal was often less than optimum for release of advance regeneration.

Figure 17.—The regeneration establishment period can be bypassed if adequate amounts of advance regeneration can be protected while removing the overstory.

Many, but not all, trees comprising advance regeneration are potential crop trees. Observations that advance regeneration responded to release appear repeatedly in the field notes, and there is independent supporting evidence that advance regeneration will respond to release (Hallin 1959, Helms and Standiford 1985). The stand establishment period can be bypassed and a long step taken into the next rotation if adequate amounts of suitable advance regeneration can be protected during a relatively short conversion period (fig. 17).

An arbitrary 10-year reentry cycle does not meet the silvical needs of stands with abundant advance regeneration. Complete removal of scattered overstory is desirable in the first cut when an area is already adequately stocked. Felling and skidding direction should be controlled to minimize damage during removal of overstory from regeneration thickets where it no longer serves a useful purpose. To accomplish this on the steeper slopes without inflicting excessive damage to the regeneration is a real challenge. But that challenge must be met sooner or later during use of the shelterwood system. So the learning process might as well start right away on areas already adequately stocked.

If adequate stocking of regeneration is the guiding criterion, residual overstory should be removed promptly from much of the partially cut acreage. At time of sampling, 78 percent of the partial cut plots had 70-percent stocking or greater from a combination of advance and subsequent regeneration. The stocking is sufficient if it is of good quality and is preserved during overstory removal.

Nearly half of the partial cuts are already overstocked. Total stocking was 90 percent or greater on 41 of the 87 partial cuts sampled. At this stocking level, natural regeneration might average 1,400 trees per acre (3,460 per ha) (Bever and Lavender 1955). Some of the poor growth noted was the result of excessive numbers of saplings. Because accretion of seedlings continues in partial cuts, additional acreage will soon become overstocked. Adequacy of regeneration should be assessed periodically in partial cuts so that overstory is removed on a timely basis, seedling accretion is halted, and the new stand is fully released.

Growth of advance regeneration could often be enhanced by thinning as soon as the regeneration has stabilized after removal of the overstory. There is some danger that newly exposed stems may sunscald if overstory removal is too sudden and drastic. Little such damage was noted, but neither was any emphasis placed on taking note of it. Risks of exposure damage could be assessed readily and rapidly on the variety of released regeneration already available.

Overstory mortality from exposure, growth rate of residual trees and stands, spread of mistletoe from mature trees to regeneration, damage caused by successive entries into the stand, stimulation of hardwood and brush competition, and other factors are important elements of a decision to foster regeneration through use of shelterwood. Their evaluation was not within the scope of this study.

Regeneration in Clearcuts

Total stocking in clearcuts averaged almost as much as in partial cuts—77 vs. 81 percent (table 15, appendix). Likewise, almost the same amount of clearcut acreage had at least 50-percent stocking—89 vs. 94 percent; 70 vs. 78 percent was well stocked. Only five plots did not have 50-percent total stocking; two were located in the Applegate area on northeast aspects, one in the Evans area on a northwest aspect, and two in the Galice-Glendale area on southerly aspects. These five plots had in common that they were on moderate to steep slopes, were cable-logged in the early 1960's, had a 1- to 3-year gap between time of logging and any planting, and now had a heavy cover of brush. They were in the Douglas-fir forest type but were widely scattered, at different elevations, on four different soil series, and three had been broadcast burned and one spot burned. Direct seeding was tried on two plots before any planting was done; and on at least two plots plantings were minimal—at 10- by 10- and 12- by 12-foot (3.0- by 3.0- and 3.7- by 3.7-m) spacings. Serious animal damage was also noted on three of the areas. A prompter regeneration effort and planting at denser spacing are required on clearcuts under currently recommended reforestation practices.

In the Siskiyou part of the Medford District, the mix of reforestation methods used in clearcuts from 1956 to 1971 produced results similar to those in partial cuts. Neither the overall stocking average, the averages for individual areas, nor the various analyses examining associations between stocking and environmental factors identify specific locations or situations where clearcutting should be avoided. Because some losses can be expected when overstory is removed, the net stocking from clearcutting may eventually be equal to or greater than that from partial cutting.

In choosing the clearcut system as well as specific reforestation practices, prudent use should be made of information on where stocking was found to be high or low. Undue emphasis should not be placed, however, on rankings founded on just a few plots. For example, low total stocking (30 percent) of the same plot substantially lowered the average for soil series 718 represented by only three plots and for the Applegate River drainage represented by four plots. Correlation analyses indicated that stocking in clearcuts tends to be greater on slopes where radiation index is low rather than high (slopes that incline away from the sun vs. those that do not), and where there are larger amounts of disturbed seedbed available. An inverse correlation between stocking of subsequent regeneration and radiation index has also been identified in other studies (Graham and others 1982; Minore and others 1982, 1984).

All clearcuts sampled except one had been planted or seeded, but artificial regeneration efforts had often been delayed. On half of the clearcuts, 1 to 3 years elapsed between the spring after harvest and the first artificial reforestation effort. On 18 of the areas, the initial artificial reforestation effort was a broadcast or spot seeding. In all but 6 of the 18, seeding was supplemented by planting 1 to 5 years later. Consequently, tree establishment was more difficult than if clearcuts had been planted at the first opportunity. Such protracted reforestation periods permitted heavy development of competing vegetation and build-up of animal populations. It is not certain how often site preparation of any kind accompanied delayed planting.

The regeneration found on clearcuts was a mix of advance and subsequent naturals, seedlings from broadcast or seed-spotted seed, and from planted nursery stock. Slash had been broadcast burned on 14 clearcuts, spot burned on 13 clearcuts, and not burned on 20 clearcuts. There were, therefore, substantial opportunities for advance regeneration to be a stocking component in clearcuts.

Subsequent regeneration was classified as from natural seedfall, seeding, or planting, but identification was not absolutely certain on some areas where successive regeneration efforts involved the same species and seedlings of similar ages. Based on the field classification of individual seedlings, six-tenths of the subsequent stocking that established on clearcuts was the result of artificial reforestation. Natural regeneration contributed substantially, four-tenths of the total, if considered a supplement to artificial regeneration. Stocking from natural regeneration was actually greater because the two components of subsequent stocking overlap rather than being additive; many individual subplots were stocked with both natural and artificial regeneration. Based on the age of the clearcuts and the quantity of seedlings less than 2 years old found during sampling, additional stocking appears unlikely.

Survey data do not adequately show how well natural regeneration alone or artificial seeding alone contributed to subsequent stocking. The one Evans plot with no record of artificial reforestation had a total subsequent stocking of 45 percent. Six other Evans plots, whose records indicated that all Douglas-fir regeneration was of natural origin, had 40- to 80-percent stocking of this species. Four plots in Galice-Glendale, where Douglas-fir seed was broadcast, averaged 73-percent stocking for this species (range 60-90). Thus, some clearcuts reforested adequately from seed alone—either from natural seedfall or from broadcast seeding, or both, but most subsequent stocking was the result of planting plus regeneration from seed. Under favorable circumstances, primary reliance might sometimes be placed on an impending seed crop or on broadcasting of seed in the Evans and Galice-Glendale areas.

Douglas-fir and ponderosa pine were the main species planted or seeded. Where used, sugar pine was spot seeded (fig. 18). Jeffrey pine was planted in five locations and white fir in one. Most ponderosa pine stocking was from planting or seeding because seed trees of this species were generally sparse. Ponderosa pine is native in many but not all of the locations in which it was planted. It generally

Figure 18.—In a few clearcuts, sugar pine was established by seedspotting.

establishes readily but may be damaged later by snow and porcupines. The advisability of establishing plantations heavily dominated by ponderosa pine is discussed under "Species Composition."

Heavy brush competition, damage from animals, and lack of seedbed disturbance hindered regeneration in clearcuts. Another obstacle, intrinsic difficulty in getting regeneration established, might be inferred from repeated artificial reforestation efforts. Because of initial reliance on natural regeneration, on direct seeding, or on planting at wide spacing, accompanied by delayed followup, the artificial reforestation efforts were not as effective as they can be. Either improvement in the timing and choice of reforestation techniques or loss of stocking as clearcuts get older can be implied by the negative correlations between stocking and age of clearcut that appeared in the statistical analyses. Despite the obstacles indicated, reforestation of clearcuts has been generally satisfactory. If improvements since 1971 in nursery stock quality, handling practices, planting techniques, site preparation, and vegetation control are considered, one must conclude that for the Siskiyou part of the District, reforestation of clearcuts, primarily by planting, should prove even more successful today.

Species Composition

Douglas-fir is the dominant regeneration in all partial cuts and in Applegate and Galice-Glendale clearcuts (figs. 9 and 10). It shares dominance with ponderosa pine in Evans clearcuts. There is a good mix of other species interspersed with Douglas-fir in all three areas. A preponderant role for true firs does not seem to have been fostered by the partial cutting that has been done, as was evident in Dead Indian (Stein 1981). Instances were observed in partial cuts where Douglas-fir and ponderosa pine regeneration was sparse in relation to cones produced by the available seed source, whereas incense-cedar regeneration seemed relatively abundant wherever there was any source of seed. The impression was gained, too, that much of the pine seed source was removed in the initial cut, which eliminated the possibility for pines to be equitably represented in the subsequent regeneration.

Ponderosa pine has been planted in several clearcuts where it was absent before, but present in the vicinity. These plantings are vulnerable—the pine may do fine or it may suffer excessive damage from snow or other causes before it reaches commercial size. The risk does not seem too great provided a mix of species becomes dominant, as seems to be occurring in many clearcuts (table 1). Jeffrey pine is appropriate for planting on serpentine areas, but planting it elsewhere appears far riskier than the risks involved with extended planting of ponderosa pine. There probably is an important ecologic reason why Jeffrey pine is commonly found on serpentine soils but not elsewhere in southwestern Oregon.

A mix of conifers should be the reforestation goal in most of the Applegate, Evans, and Galice-Glendale areas. Stand components should vary by locality; when rust-resistant stock is available, sugar pine should often be included. Mixed stands are recommended based on the long-term vegetation trends (Detling 1968), the structure of present stands, and the practical objectives of management.

Management for a mix of local conifers requires that overstory be opened sufficiently to permit seral species, such as Douglas-fir, ponderosa pine, sugar pine, and incense-cedar, to become established and to make good growth. Mixed conifer

stands could probably be established solely through natural regeneration, but results might often be slow and uncertain. To achieve intensive forestry, major reliance will have to be placed on planting. The uneven distribution of desired seed trees, the infrequency and untimeliness of seed crops, the need for reforesting prepared sites immediately, and the desirability of controlling species, genetic quality, and tree spacing all dictate that reforestation not be left solely to "Mother Nature." It is certain, however, that natural regeneration will supplement the basic stocking established in clearcuts by artificial reforestation. Control of species and time of regeneration establishment may also be desirable in shelterwoods where advance regeneration is not abundant. Underplanting appears desirable in some shelterwoods followed by careful evaluation of results.

Stand Prescriptions

No single harvesting system should be designated as standard for the varied stands in the Applegate, Evans, and Galice-Glendale areas. Silvicultural practices need to be applied almost on an acre-by-acre basis. Some stands need to be left untouched for a while to develop; sapling and pole patches need complete release from overstory; and dense stands need either a salvage cut, a shelterwood cut, or clearcutting. For shelterwoods, the suitability and vigor of prospective leave trees need careful scrutiny to minimize the scattered, unpredictable mortality that follows every harvest entry. Such scrutiny should include a search for mistletoe in the overstory and advance regeneration to prevent perpetuation of infected stands.

The first step needed to get this mosaic of forest stands under intensive management is to define specific goals (stocking, species mix, and so forth), area by area. The silvicultural alternatives available to attain the goals should then be considered, and the most suitable ones chosen. The technical basis for that choice should be written out. This facilitates review by subject matter specialists; more important, it provides the vital communication needed to maintain on-the-ground direction and continuity. A written stand prescription forms the basis for action and provides a target for periodic measurement of progress.

Use of Correlations and Equations

Many correlations and equations are included in this report. These were the basis for some of the conclusions and recommendations, but their inclusion serves another major purpose. They are working tools the silviculturist can use.

The regression equations describe, by separate regeneration categories, stocking patterns that may not be discernible when individual stands are viewed. Each equation shows, for a particular area or forest type, the environmental variables that surfaced as most important in the mathematical analysis of the stocking data. The variables are listed in order of importance, and the fraction of the total variation accounted for (cumulative R^2) is shown. The numerical values are unique to the equation as listed—delete or add one variable and a different set of values applies. The plus and minus signs in the equation do not indicate for certain whether individual variables had a positive or negative association with stocking; this information is given by the correlation coefficients for single variables.

Neither regression equations nor correlation coefficients identify actual biological cause-effect relationships between environmental variables and stocking. They constitute tests of association—that a dependent variable (stocking) and one or more independent variables are varying in concert, either directly or inversely. Biological

inferences may be drawn from associations found significant, provided the basis for a cause-effect relationship has already been established independently; such relationships are not proved just because certain associations are shown to exist.

The correlation coefficients should prove useful in preparing prescriptions for establishment of particular species or species mixes. The sign of its correlation coefficient indicates whether stocking was positively or negatively associated with each environmental variable listed. For example, stocking of subsequent Douglas-fir in Applegate was shown to be negatively associated with increases in canopy, duff and litter, and undisturbed seedbed (table 26, appendix). If the silviculturist wants to favor establishment of Douglas-fir, the prescription for natural regeneration should call for a sparse canopy and good disturbance of seedbed. Perhaps not all applicable, significant variables can be accommodated in a prescription for one species, much less for a mix of species. But by giving attention particularly to associations that are common to more than one species, forest type, or area, the silviculturist has guidance based on past local performance that is much better than guesswork.

In using these regressions and correlations, silviculturists must keep in mind limitations of the data base. The data for partial cuts are from stands subjected to one entry which left 19 to 80 percent canopy (table 4). Variability of the original overstory was great, no marking rule was applied systematically, and all regeneration had established naturally. The data for clearcuts are from older areas with a varied history of planting and seeding. Artificial regeneration efforts were often delayed several years. None of the equations reflect what may be possible with the most up-to-date site preparation and reforestation technology, but one might reasonably expect that most of the same variables would have a strong influence.

An Overview

This study was initiated because there were broad and critically important questions about the effectiveness of silvicultural practices used by the Medford District to establish regeneration. Results reported in this paper and in Research Paper PNW-284 (Stein 1981) comprise a comprehensive and detailed evaluation of the regeneration produced by past silvicultural practices. Opportunities for improvement are evident from the data as well as from the foregoing interpretive remarks. But beyond the actual study results, there is a broader arena where technical, practical, and philosophical considerations need melding because the overall approach has an important bearing on regeneration success. Such matters are discussed in the next few paragraphs.

When selecting silvicultural systems, better use should be made of existing information—the accumulated experiences available in District files, among practitioners, in the literature, **plus** the record on the ground. A keen observer can learn much from the large variety of overstory conditions and regeneration results already available. Bluntly stated, it is silviculturally unsound to apply only the shelterwood system or only the clearcut system when dealing with forests on the District that vary immensely in species composition, age classes, densities, topography, soils, climate, vegetative competition, and many other factors. Judicious use must be made of all systems by foresters who have a good technical background, information from local studies, and an intimate knowledge of conditions on the ground.

A flexible approach is also needed in choice of system components—to broadcast burn, spot burn, or not burn slash; to remove or not remove overstory hardwoods; to treat or not treat hardwood stumps to prevent sprouting; to rely on natural regeneration or to regenerate artifically with which species and what size of stock; to permit or prevent overtopping of crop trees by competing vegetation, and by what means; and so forth.

Sufficient information and experience are now available to provide direction for placing these virgin forests under silvicultural management. Certainly, not all the answers are available—nor will they ever be! A rotation from now, alert foresters will still be asking more technical questions than anyone has answers for. Research can and should supply more answers than are now available, but all of the answers and guidelines will only assist, not substitute for judgments that must be made on the ground. Silviculture is a science and an art that must be practiced locally, area by area, using the best information that is available. Where information is scarce, conservative approaches and trials are called for rather than inaction, otherwise the needed experience may never develop.

In total, the data from this survey indicate that past silvicultural practices have yielded reasonably good regeneration establishment on most of the District. To a degree, the data are deceptive—they confirm that healthy live trees are in place but provide little indication as to how well these trees are developing to form fast-growing stands. Field notes clearly indicate that some of the regeneration is growing slowly, needs release from brush or overstory, or needs thinning. Limited supplemental data taken in the Siskiyou areas may indicate how fast dominant trees on stocked plots are growing, but they will not indicate what the potential might be if more intensive regeneration practices were used. Knowledge of growth rates obtainable by the methods used and by alternate methods is vital if the projected benefits of intensive forestry are to be realized.

Regeneration practices can be improved to yield higher, more uniform stocking, and faster seedling growth. A number of ways to improve practices are well known, and improvements over past practices, which involved much trial and error, have already been made. Intensive reforestation practices are costly, but unsuccessful reforestation attempts are even more costly. Hence, a primary goal must be to employ a sufficiently intense reforestation method to consistently guarantee minimum success. Added increments of effort then depend on what can be realized in added growth and other benefits. Much administrative and research information must still be developed before returns are known for such incremental efforts.

Figure 19.—Growth of perennial vegetation must be curbed in many areas if tree seedlings are to survive and grow satisfactorily.

Broadly speaking, improved vegetation management is the best means for improving regeneration survival and growth (fig. 19). Opportunities for improvement start with manipulation of the initial stand—the amount, distribution, and composition of overstory left uncut in shelterwoods, and the level of residual trees and brush allowed to remain in clearcuts. Timely establishment of regeneration is important. So important that little delay can be tolerated, perhaps even in shelterwoods. A viewpoint expressed long ago for clearcuts in southwestern Oregon has stood the test of time (Stein 1955):

> The single most important thing forest managers can do to minimize difficulties in obtaining artificial regeneration is to reforest cutover areas promptly. Rodents, cutworms, and competing vegetation are at their lowest concentration immediately after a tract has been logged and burned. Each succeeding year increases the difficulties that must be overcome to obtain adequate stocking of the cutover tract.

Finally, reforestation areas and newly regenerated stands must receive continuing attention. Too often, a reforestation effort has become less effective than it could have been because failed areas were not detected soon enough, damage to trees was not prevented, and growth of hindering vegetation was not held in check. It is not certain that past replanting efforts were either timely or accompanied by appropriate vegetation control. Keeping reforestation records updated, making periodic examinations as scheduled, and tending to plantation needs promptly are vital parts of good reforestation practice.

Problems to Solve

As in every other forested area, there are reforestation problems to solve in the Applegate, Evans, and Galice-Glendale areas. These problems may loom large locally but need to be viewed in perspective. The forest conditions in the western part of the Medford District are no hotter and drier than they are farther east or south where the same forest types grow in southern Oregon and northern California. Forests have established here naturally and in abundance; by understanding the influencing variables sufficiently, silviculturists should be able to identify ways to speed and otherwise control the process.

Problems to solve are discussed on the premise that reasonably intensive timber management will be practiced—that timber production is a primary objective. Relative importance of the problems would change markedly if management objectives were substantially different. Two additional premises also influence choice of solutions: (1) when desired, an adequate amount of regeneration can be saved during partial or complete removal of initial overstory or of shelterwood, and (2) large-scale harvest-system studies are neither the best nor the quickest way to get the kind of answers needed. Skimpy evidence indicates that stocking of seedlings and saplings may not be reduced seriously if overstory removal is carefully planned—18 percent of marked trees in pine stands of central Oregon (Barrett and others 1976); 4 percent of total milacre stocking in the ponderosa pine type of northern California (McDonald 1969); and 10 percent of 4-milacre stocking (personal observation) or 4 percent of planted trees (Tesch 1982) in the mixed conifer type of western Oregon.

Overstory Required

Survey results indicated that stocking was sometimes positively correlated with and other times was negatively correlated with the amount of overstory canopy, but often there was no correlation. In partial cuts, stocking tended to be higher on slopes most exposed to the sun compared to those least exposed; in clearcuts stocking tended to be just the reverse. Clearly, canopy influences regeneration establishment in some way wherever it occurs. Where is it really needed and what amount of canopy should be retained?

Overstory canopy ameliorates strong sunlight, slows wind movement, and reduces outgoing radiation. On the other hand, overstory competes with advance and subsequent regeneration for soil moisture and curtails rate of seedling growth. Thus, it is desirable to retain only sufficient overstory to foster establishment of the desired species. The amount of overstory required for different species and circumstances needs much better definition.

Severe frost during the growing season does not appear to be a widespread reforestation problem in the western part of the District. Cold air drains from the steep slopes and middle elevations so common in the Applegate, Evans, and Galice-Glendale areas. Accumulation of cold air in valley bottoms and lower slopes is a certainty, though, and localized frost hazard areas are likely. Answers developed for Dead Indian (Stein 1981) on the identification of frost hazards and the amount of canopy needed to protect regeneration should suffice for solving frost problems in the rest of the District.

Competing Vegetation

Throughout the Applegate, Evans, and Galice-Glendale areas, generous quantities of perennial and annual vegetation develop to compete with tree seedlings for moisture and light. Where rainfall is not abundant, the critical competition is probably for moisture; where rainfall is reasonably abundant and competing vegetation grows lush and tall, seedlings are often overtopped by shrubs or hardwoods and the critical limiting factor for seedling survival and growth may be light. Because reduced light also affects root development, seedling growth may often be slowed because of the combined effects of light and moisture deficiencies.

There are several broad classes of competing vegetation—the residual overstory itself; tall hardwoods such as California black oak, tan oak, canyon live oak, giant chinkapin, Pacific madrone, bigleaf maple, and red alder; woody perennials including manzanitas, ceanothus, snowberry, ribes (*Ribes* sp.), poison oak, vine maple, huckleberries (*Vaccinium* sp.), and thimbleberry; and annuals such as grasses, fireweeds, thistles, and groundsels. Each group has its competitive pecularities, which are disadvantageous to tree seedlings, as well as helpful characteristics. Representatives of the four groups occur in countless mixtures. Their potential for adverse effects on tree seedling survival and growth has been amply demonstrated (Cleary 1978, Nolan 1978, Roy 1979, Stewart and others 1984), but definition of circumstances where competition is actually unacceptably severe remains burdened with uncertainty (fig. 20).

Soil moisture is depleted far more during the growing season under forest stands than in clearcuts (Bethlahmy 1962). Consequently, reduction of overstory increases the moisture available for seedling establishment, provided evaporation rates from surface layers do not become excessive or competing low vegetation overly dense. Vegetation that develops on cutovers may soon increase moisture depletion to nearly the same level as in uncut stands (Hallin 1967, 1968). Moisture available to seedlings under different amounts of overstory and with different amounts and kinds of competing vegetation has never been adequately defined. Advance growth among seed trees appeared to adversely affect establishment of natural regeneration in California (Hall 1963).

Research progress is needed simultaneously on two aspects of the vegetative competition problem—on development of techniques to readily evaluate severity of existing competition, and on continued development of an array of effective and acceptable methods for preventing or reducing undesirable competition.

Systematic study of soil moisture should define the locations, soils, and vegetative conditions where drought truly limits establishment of regeneration. Availability of moisture during the growing season could be checked rapidly in upper soil layers by gravimetric methods or neutron probe, and moisture stress levels in seedlings or

Figure 20.—A key problem to solve: How much vegetative competition is too much?

associated vegetation by pressure bomb readings. When moisture-deficient situations are clearly identified, control of vegetation and other moisture-conserving techniques can be concentrated where they are needed most.

A variety of vegetation control methods are under investigation, but research on moisture availability is sparse. Light requirements for trees and shrubs under field conditions have received limited study (Atzet and Waring 1970, Del Rio and Berg 1979, Emmingham and Waring 1973, Isaac 1963, Strothmann 1972).

Animal Damage

As in all forested areas, regeneration in the Applegate, Evans, and Galice-Glendale areas is damaged to some extent by animals. Damage by elk, deer, and mountain beaver, and perhaps by woodrats, was noted in examining plots; gopher activity was usually not prominent enough to be recorded. The level of stocking indicates that animal damage has not prevented establishment of sufficient regeneration, but browsing of seedlings that checks height growth may be abetting the overtopping from competing vegetation. Replanting efforts might also have been necessary because of damage inflicted by animals on seedlings of the initial planting or seeding.

Occurrence of animal damage is common and apparently increasing on regeneration in southwestern Oregon (Evans and others 1981). The District needs to identify current and likely problem areas and take necessary steps to keep such damage to

acceptable levels. Specific studies are probably not necessary, but an ongoing effort to discover problem locations on a timely basis is necessary. Localized problems may include some damage from domestic livestock.

Growth of Regeneration

Information on growth rate is needed for two important criteria that influence choice of reforestation system: (1) among advance regeneration, what species and which trees have the capability to respond promptly to release and attain normal growth? and (2) what are typical growth rates for regeneration under different densities of canopy? An answer to the first question would identify the advance regeneration worth saving. An answer to the second question would define overstory densities that foster reasonable growth of natural or planted regeneration. Ferguson (1984) elaborates on the need for guidelines that define acceptable advance regeneration.

Response to partial or complete release can be determined by measuring regeneration released some years previously or by releasing regeneration and observing its subsequent growth. Two studies based on the first approach are most pertinent to stands in the western Siskiyous. A model for predicting growth response of released white fir, California red fir (*Abies magnifica* A. Murr.), and Douglas-fir in northern California, based on prerelease characteristics observable later, was developed by means of regression techniques (Helms and Standiford 1985). Comparisons of growth before and after showed that sugar pine saplings respond to partial release in the South Umpqua drainage of Oregon (Hallin 1959). Data in both studies were obtained from trees released some years previously; thus, knowledge of actual tree appearance (except for height and diameter) and overstory, understory, and competing vegetation present at time of release was inadequate; needle complements and tree crowns fill out, and associates change markedly in a few years. Correlations between tree and site conditions at time of release and subsequent growth are easy to obtain, but several years are required for marked trees to respond. Identifying the trees that respond to release answers only part of the question; one must also determine if the postrelease growth rate compares favorably with growth of subsequent regeneration.

Stand Ecology

Throughout the western part of the Medford District, mixed conifer stands of varied composition occur. Such variety may be attributable to the happenstances of species mix in the seed fall when sites were ready for seedling establishment; or the stand variations may form definite patterns that provide clues on species limitations, microsite differences, and ecological trends.

Ecological studies to better understand existing stands—their nature, origin, and successional trends—could yield valuable insights for management of these mixed stands. Knowledge of successional trends and of stand origins might indicate how to work in concert with nature rather than in opposition. Some information on stand structure and age was developed by Graham and others (1982) and Minore and others (1982) while investigating relationships between environmental factors and establishment of subsequent regeneration in the Applegate and Hungry-Pickett localities that are within the territory covered by this survey. The role of individual species, in particular sugar pine, should be defined better. Sugar pine is one of the best growing species in the mixed conifer type and should be perpetuated wherever rust hazard is low or when resistant seedlings or planting stock are available.

Other Opportunities

The foregoing discussion of problems dealt with broad topics that may each require substantial research effort for adequate solution. A variety of smaller efforts that merit administrative or research attention should also be mentioned.

1. Try to determine why stocking was significantly lower in one geographic area or drainage than in another—for example, why did stocking of a few clearcuts average lower in the Applegate River drainage than in adjacent drainages? were the original stands different? do the cutovers differ substantially in environmental traits? were they treated differently? or was a different level of regeneration effort applied? An administrative effort to gather and compare existing information is the first step. Answers might become self-evident, or a need for further study might surface.

2. Compare techniques for removing residual overstory to learn how to save enough well-distributed advance and subsequent regeneration.

3. Institute a monitoring system to determine effectiveness of artificial reforestation efforts. Do planted or seeded trees or natural regeneration constitute most of the crop trees in cutovers? The clearest way to answer this question is to stake an adequate sample of planted or seeded trees on every cutover and reexamine them periodically. In a few years, the actual success of artificial reforestation efforts will become abundantly clear.

4. Determine if it is worthwhile to control undesirable hardwoods in partial cuts so they do not cast seed or rapidly encroach on regeneration. Likewise, determine if it is good practice to treat hardwood stumps in clearcuts.

5. Investigate how sufficient seedbed can be disturbed, particularly during cable logging, wherever natural regeneration is desired.

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Appendix

Data sources, collection methods, and summation procedures for descriptive and environmental variables.

1. Elevation—height above mean sea level was extrapolated to the nearest 10 feet (3 m) from the plot's location on the applicable U.S. Geological Survey quadrangle map.

2. Average slope—steepness of slope was estimated ocularly to the nearest 10 percent and checked occasionally with a clinometer. Observations for individual subplots were summed and a plot average determined.

3. Aspect index—slope direction was rated to the nearest of eight main compass points. A numerical relative moisture value was then assigned to each subplot from the scale derived by Day and Monk (1974). Values for subplots were summed and a plot average determined.

4. Radiation index—a yearly solar irradiation value was determined for each subplot by entering the subplot's slope and aspect in a table of radiation indexes for latitude 42° north as calculated by Frank and Lee (1966). Values for subplots were summed and a plot average determined.

5. Average annual precipitation—yearly rainfall was extrapolated to the nearest 2 inches (51 mm) from the plot's approximate location on a small-scale isohyet map of Oregon.

6. Forest type and age class—the general prelogging composition, density, and age of the forest stand were determined from the plot's location on a forest type map. Such maps were prepared in the 1940's as part of the nationwide Forest Survey by the Pacific Northwest Forest and Range Experiment Station, USDA Forest Service. In mixed stands, only 20 percent or more of an associated species, such as sugar pine, needed to be present to qualify as the associated type.

7. Soil type—soil series were identified from soil inventory maps and descriptions prepared for the Medford District, Bureau of Land Management (deMoulin and others 1975).

8. Years since logging—timber harvest dates for the cutover area encompassing each plot were obtained from cutting reports for individual sales. Years since logging are based on the number of complete growing seasons (ending September 1) between cutting date and examination date. Determined this way, elapsed time data best reflect the actual establishment period available for tree seedlings and fit with the development stage for judging when seedlings are 2 years old or less.

9. Canopy—total vegetative cover present at waist height and above, directly over the subplot, was estimated visually to the nearest tenth of the subplot area. Estimates for individual subplots were summed and a plot average determined.

10. Seedbed—the surface condition judged predominant on the subplot immediately after logging was classed as one of five types: bare mineral soil; undisturbed duff and litter; disturbed soil, duff, and litter; mixed soil and rock; or logs, wood, and bark. Duff- and litter-covered subplots and those covered with logs, wood, and bark were counted separately and computed as a percentage of the total subplots on the plot.

11. Seed source—distance to the nearest seed tree was judged as within 50 feet (15.2 m) or over 50 feet in 100-foot (30.5-m) classes. The nearest 16-inch (41-cm) d.b.h. or larger tree with a reasonably full crown was usually considered a source of seed. Trees smaller than 16 inches were recognized if there was evidence they had borne seed in substantial quantities. The species of the nearest seed tree was also recorded. Separately, subplots with a seed tree of any species, of Douglas-fir, or of true fir, within 50 feet, were counted and computed as a percentage of the total subplots on the plot.

12. Ground cover—total vegetative cover present below waist height was estimated visually to the nearest tenth of the subplot area. Estimates for individual subplots were summed and a plot average determined.

13. Dominant ground cover—vegetative cover was classed as the predominant one of three broad types: grass, herbaceous, or woody perennial. For subplots dominated by woody perennials, the genus or species was recorded if one clearly dominated. Separately, subplots dominated by grass or by woody perennials were counted and computed as a percentage of the total subplots on the plot.

Table 15—Average stocking in cutovers in the Applegate, Evans, and Galice-Glendale areas

Descriptor	Partial cuts	Clearcuts
Applegate:		
Number of samples	35	15
Regeneration class (percent ± standard error) 1/--		
All	76.4 ± 3.5	70.7 ± 5.4
Advance	40.0 ± 4.5	14.0 ± 3.5
Subsequent	58.0 ± 3.5	64.7 ± 5.2
Second-year 2/	2.1 ± 0.6	1.0 ± 0.5
Evans:		
Number of samples	25	15
Regeneration class (percent ± standard error) 1/--		
All	79.8 ± 2.7	83.7 ± 3.9
Advance	51.8 ± 4.5	23.7 ± 4.9
Subsequent	52.0 ± 4.1	74.7 ± 5.4
Second-year 2/	4.2 ± 1.4	0.
Galice-Glendale:		
Number of samples	27	17
Regeneration class (percent ± standard error) 1/--		
All	87.4 ± 3.1	75.9 ± 4.9
Advance	65.2 ± 4.6	20.3 ± 6.6
Subsequent	56.3 ± 4.4	72.6 ± 4.6
Second-year 2/	4.6 ± 1.9	0.6 ± 0.4
Combined:		
Number of samples	87	47
Regeneration class (percent ± standard error) 1/--		
All	80.8 ± 1.9	76.7 ± 2.8
Advance	51.2 ± 2.8	19.4 ± 3.0
Subsequent	55.7 ± 2.3	70.7 ± 2.9
Second-year 2/	3.5 ± 0.8	0.5 ± 0.2

1/ Data for regeneration classes are not additive as more than 1 class was found on many subplots.

2/ Not included in the "All" and "Subsequent" classes.

Table 16—Proportion of sample plots stocked at 4 levels with regeneration

Stocking at least	Plots	Proportion of total	Confidence limit 1/ Lower	Confidence limit 1/ Upper
Percent	Number	Proportion	Proportion	Proportion
		35 APPLEGATE PARTIAL CUTS		
30	35	1.00	0.90	1.00
50	31	.89	.73	.97
70	25	.71	.54	.85
90	15	.43	.26	.61
		25 EVANS PARTIAL CUTS		
30	25	1.00	.86	1.00
50	25	1.00	.86	1.00
70	20	.80	.59	.93
90	9	.36	.18	.57
		27 GALICE-GLENDALE PARTIAL CUTS		
30	27	1.00	.87	1.00
50	26	.96	.81	1.00
70	23	.85	.66	.96
90	17	.63	.42	.81
		15 APPLEGATE CLEARCUTS		
30	15	1.00	.78	1.00
50	13	.87	.60	.98
70	9	.60	.32	.84
90	4	.27	.08	.55
		15 EVANS CLEARCUTS		
30	15	1.00	.78	1.00
50	14	.93	.68	1.00
70	14	.93	.68	1.00
90	8	.53	.27	.79
		17 GALICE-GLENDALE CLEARCUTS		
30	17	1.00	.80	1.00
50	15	.88	.64	.99
70	10	.59	.33	.82
90	8	.47	.23	.72

1/ There is a 95-percent or greater chance that the true proportion is within lower and upper confidence limits.

Table 17—Proportion of sample plots stocked at 4 levels with advance regeneration

Stocking at least	Plots	Proportion of total	Confidence limit 1/ Lower	Upper
Percent	Number	Proportion		
		35 APPLEGATE PARTIAL CUTS		
30	21	0.60	0.42	0.76
50	12	.34	.19	.52
70	10	.29	.15	.46
90	0	0	0	.10
		25 EVANS PARTIAL CUTS		
30	21	.84	.64	.95
50	16	.64	.43	.82
70	7	.28	.12	.49
90	1	.04	0	.20
		27 GALICE-GLENDALE PARTIAL CUTS		
30	26	.96	.81	1.00
50	19	.70	.50	.86
70	15	.56	.35	.75
90	5	.19	.06	.38
		15 APPLEGATE CLEARCUTS		
30	3	.20	.04	.48
50	0	0	0	.22
70	0	0	0	.22
90	0	0	0	.22
		15 EVANS CLEARCUTS		
30	7	.47	.21	.73
50	2	.13	.02	.40
70	0	0	0	.22
90	0	0	0	.22
		17 GALICE-GLENDALE CLEARCUTS		
30	3	.18	.04	.43
50	3	.18	.04	.43
70	2	.12	.01	.36
90	1	.06	0	.29

1/ There is a 95-percent or greater chance that the true proportion is within lower and upper confidence limits.

Table 18—Proportion of sample plots stocked at 4 levels with subsequent regeneration

Stocking at least	Plots	Proportion of total	Confidence limit 1/ Lower	Confidence limit 1/ Upper
Percent	Number	Proportion		
		35 APPLEGATE PARTIAL CUTS		
30	33	0.94	0.81	0.99
50	22	.63	.45	.79
70	12	.34	.19	.52
90	6	.17	.07	.34
		25 EVANS PARTIAL CUTS		
30	22	.88	.69	.97
50	15	.60	.39	.79
70	6	.24	.09	.45
90	1	.04	0	.20
		27 GALICE-GLENDALE PARTIAL CUTS		
30	23	.85	.66	.96
50	19	.70	.50	.86
70	9	.33	.17	.54
90	2	.07	.01	.24
		15 APPLEGATE CLEARCUTS		
30	15	1.00	.78	1.00
50	11	.73	.45	.92
70	6	.40	.16	.68
90	3	.20	.04	.48
		15 EVANS CLEARCUTS		
30	14	.93	.68	1.00
50	13	.87	.60	.98
70	11	.73	.45	.92
90	4	.27	.08	.55
		17 GALICE-GLENDALE CLEARCUTS		
30	17	1.00	.80	1.00
50	15	.88	.64	.99
70	10	.59	.33	.82
90	5	.29	.10	.56

1/ There is a 95-percent or greater chance that the true proportion is within lower and upper confidence limits.

Table 19—Proportion of sample plots stocked at 4 levels with subsequent Douglas-fir

Stocking at least	Plots	Proportion of total	Confidence limit 1/ Lower	Upper
Percent	Number	Proportion		
		35 APPLEGATE PARTIAL CUTS		
30	28	0.80	0.63	0.92
50	15	.43	.26	.61
70	8	.23	.10	.40
90	4	.11	.03	.27
		25 EVANS PARTIAL CUTS		
30	17	.68	.46	.85
50	10	.40	.21	.61
70	5	.20	.07	.41
90	1	.04	0	.20
		27 GALICE-GLENDALE PARTIAL CUTS		
30	19	.70	.50	.86
50	14	.52	.32	.71
70	5	.19	.06	.38
90	1	.04	0	.19
		15 APPLEGATE CLEARCUTS		
30	12	.80	.52	.96
50	7	.47	.21	.73
70	5	.33	.12	.62
90	2	.13	.02	.40
		15 EVANS CLEARCUTS		
30	13	.87	.60	.98
50	5	.33	.12	.62
70	3	.20	.04	.48
90	0	0	0	.22
		17 GALICE-GLENDALE CLEARCUTS		
30	16	.94	.71	1.00
50	12	.71	.44	.90
70	7	.41	.18	.67
90	3	.18	.04	.43

1/ There is a 95-percent or greater chance that the true proportion is within lower and upper confidence limits.

Table 20—Proportion of sample plots stocked at 4 levels with subsequent true firs

Stocking at least	Plots	Proportion of total	Confidence limit 1/ Lower	Upper
Percent	Number	Proportion		
		35 APPLEGATE PARTIAL CUTS		
30	6	0.17	0.07	0.34
50	2	.06	.01	.19
70	0	0	0	.10
90	0	0	0	.10
		25 EVANS PARTIAL CUTS		
30	3	.12	.03	.31
50	2	.08	.01	.26
70	1	.04	0	.20
90	0	0	0	.14
		27 GALICE-GLENDALE PARTIAL CUTS		
30	3	.11	.02	.29
50	0	0	0	.13
70	0	0	0	.13
90	0	0	0	.13
		15 APPLEGATE CLEARCUTS		
30	2	.13	.02	.40
50	1	.07	0	.32
70	0	0	0	.22
90	0	0	0	.22
		15 EVANS CLEARCUTS		
30	0	0	0	.22
50	0	0	0	.22
70	0	0	0	.22
90	0	0	0	.22
		17 GALICE-GLENDALE CLEARCUTS		
30	3	.18	.04	.43
50	1	.06	0	.29
70	0	0	0	.20
90	0	0	0	.20

1/ There is a 95-percent or greater chance that the true proportion is within lower and upper confidence limits.

Table 21—Average stocking by species in cutovers in the Applegate, Evans, and Galice-Glendale areas

Descriptor	Applegate	Evans	Galice-Glendale
	PARTIAL CUTS		
Number of samples	35	25	27
Species (percent ± standard error):1/			
Douglas-fir	61.7 ± 3.4	61.8 ± 3.6	78.3 ± 3.8
True firs	20.9 ± 4.6	22.0 ± 5.1	15.4 ± 5.2
Ponderosa pine	4.9 ± 1.4	10.0 ± 3.1	6.1 ± 2.5
Sugar and western white pine	10.3 ± 3.3	12.8 ± 2.9	26.7 ± 5.4
Incense-cedar	14.7 ± 3.8	35.0 ± 5.8	9.3 ± 2.8
Other conifers	7.0 ± 2.6	5.4 ± 3.3	5.2 ± 2.9
Hardwoods	5.6 ± 2.6	5.6 ± 1.7	12.4 ± 2.8
All species	76.4 ± 3.5	79.8 ± 2.7	87.4 ± 3.1
	CLEARCUTS		
Number of samples	15	15	17
Species (percent ± standard error):1/			
Douglas-fir	52.3 ± 6.5	57.7 ± 5.0	65.9 ± 6.5
True firs	12.0 ± 5.0	12.0 ± 3.0	15.0 ± 5.4
Ponderosa pine	18.7 ± 5.8	44.3 ± 6.9	7.4 ± 4.2
Sugar and western white pine	4.7 ± 2.5	5.7 ± 2.5	14.4 ± 6.8
Incense-cedar	7.0 ± 3.5	16.7 ± 5.4	8.5 ± 3.8
Other conifers	9.3 ± 5.3	6.0 ± 3.5	2.4 ± 1.8
Hardwoods	.3 ± .3	11.7 ± 4.4	3.2 ± 1.4
All species	70.7 ± 5.4	83.7 ± 3.9	75.9 ± 4.9

1/ Does not include second-year seedlings.

Table 22—Average stocking of advance regeneration by species in cutovers in the Applegate, Evans, and Galice-Glendale areas

Descriptor	Geographic area: Applegate	Evans	Galice-Glendale
	PARTIAL CUTS		
Number of samples	35	25	27
Species (percent ± standard error):			
Douglas-fir	23.6 ± 2.9	33.4 ± 3.7	54.6 ± 5.1
True firs	13.9 ± 3.4	13.8 ± 3.3	9.6 ± 3.6
Ponderosa pine	1.4 ± 1.0	5.0 ± 2.7	4.1 ± 1.5
Sugar and western white pine	4.9 ± 1.7	8.2 ± 2.0	19.8 ± 4.6
Incense-cedar	9.4 ± 3.1	26.0 ± 5.3	4.4 ± 1.3
Other conifers	3.9 ± 1.6	1.2 ± .7	2.0 ± 1.1
Hardwoods	1.4 ± .9	1.4 ± .6	12.0 ± 2.8
All species	40.0 ± 4.5	51.8 ± 4.5	65.2 ± 4.6
	CLEARCUTS		
Number of samples	15	15	17
Species (percent ± standard error):			
Douglas-fir	4.3 ± 1.8	14.3 ± 3.7	14.1 ± 5.2
True firs	3.7 ± 2.0	8.0 ± 2.5	8.2 ± 4.5
Ponderosa pine	0	.3 ± .3	0
Sugar and western white pine	2.0 ± 1.4	3.3 ± 2.2	2.4 ± 1.3
Incense-cedar	2.7 ± 2.1	2.3 ± .8	.9 ± .9
Other conifers	4.0 ± 2.1	3.7 ± 3.0	.3 ± .3
Hardwoods	0	1.7 ± .9	0
All species	14.0 ± 3.5	23.7 ± 4.9	20.3 ± 6.6

Table 23—Average stocking of subsequent regeneration by species in cutovers in the Applegate, Evans, and Galice-Glendale areas

Descriptor	Applegate	Evans	Galice-Glendale
		PARTIAL CUTS	
Number of samples	35	25	27
Species (percent ± standard error):1/			
Douglas-fir	47.9 ± 3.7	42.8 ± 4.7	45.4 ± 4.9
True firs	11.1 ± 2.9	11.0 ± 3.8	7.4 ± 2.4
Ponderosa pine	3.4 ± 1.0	6.0 ± 1.5	2.2 ± 1.4
Sugar and western white pine	6.7 ± 2.8	5.2 ± 2.1	12.8 ± 3.2
Incense-cedar	6.7 ± 1.6	13.2 ± 2.4	5.6 ± 2.4
Other conifers	3.4 ± 1.7	4.2 ± 2.9	3.7 ± 2.4
Hardwoods	4.3 ± 2.3	4.6 ± 1.5	.4 ± .4
All species	58.0 ± 3.5	52.0 ± 4.1	56.3 ± 4.4
		CLEARCUTS	
Number of samples	15	15	17
Species (percent ± standard error):1/			
Douglas-fir	49.7 ± 6.5	47.3 ± 5.1	61.2 ± 6.1
True firs	9.0 ± 4.3	4.3 ± 1.8	10.6 ± 4.0
Ponderosa pine	18.7 ± 5.8	44.0 ± 6.8	7.4 ± 4.2
Sugar and western white pine	3.0 ± 1.5	3.3 ± 1.5	12.9 ± 6.3
Incense-cedar	5.3 ± 2.6	14.7 ± 5.5	7.6 ± 3.4
Other conifers	6.3 ± 4.0	2.3 ± 1.4	2.1 ± 1.5
Hardwoods	.3 ± .3	10.0 ± 4.3	3.2 ± 1.4
All species	64.7 ± 5.2	74.7 ± 5.4	72.6 ± 4.6

1/ Does not include second-year seedlings.

Table 24—Average stocking of second-year regeneration by species in cutovers in the Applegate, Evans, and Galice-Glendale areas

Descriptor	Geographic area: Applegate	Evans	Galice-Glendale
	PARTIAL CUTS		
Number of samples	35	25	27
Species (percent ± standard error):			
Douglas-fir	1.1 ± 0.5	1.6 ± 1.1	4.1 ± 1.8
True firs	.3 ± .2	0	.2 ± .2
Ponderosa pine	.1 ± .1	0	0
Sugar and western white pine	.1 ± .1	.2 ± .2	.4 ± .3
Incense-cedar	0	2.4 ± 1.0	0
Other conifers	.4 ± .2	0	0
Hardwoods	0	0	0
All species	2.1 ± .6	4.2 ± 1.4	4.6 ± 1.9
	CLEARCUTS		
Number of samples	15	15	17
Species (percent ± standard error):			
Douglas-fir	.7 ± .5	0	0
True firs	0	0	0
Ponderosa pine	.3 ± .3	0	0
Sugar and western white pine	0	0	0
Incense-cedar	0	0	.6 ± .4
Other conifers	0	0	0
Hardwoods	0	0	0
All species	1.0 ± .5	0	.6 ± .4

Table 25—Significant associations between total or advance stocking in partial cuts and environmental variables by area

Stocking category	Environmental variable and its correlation coefficient (r) 1/ 2/							
	Applegate		Evans		Galice-Glendale		Areas combined	
Total	Slope	-0.44**	Duff and litter	0.34	Woody perennials	-0.34	Slope	-0.37**
	Years	.37*			Logs, wood, bark	-.35	Years	.23*
	Douglas-fir seed source	-.29			Precipitation	.33	Logs, wood, bark	-.20
							Douglas-fir seed source	-.22*
							Precipitation	.34**
Advance all species	Slope	-.48**	Woody perennials	-.38	Canopy	.52**	Elevation	-.27*
	Years	.39*	Duff and litter	.46*	Grass	.36	Radiation index	.19
	Duff and litter	.33	Undisturbed seedbed	.47*	Woody perennials	-.53**	Slope	-.36**
	Douglas-fir seed source	-.52**			Duff and litter	.75**	Canopy	.34**
	Precipitation	.31			Logs, wood, bark	-.49**	Duff and litter	.44**
					Undisturbed seedbed	.60**	Logs, wood, bark	-.25*
							Douglas-fir seed source	-.26*
							Precipitation	.34**
							Undisturbed seedbed	.33**
Advance Douglas-fir	Elevation	-.35*	Years	-.35	Elevation	-.35	Elevation	-.41**
	Aspect	-.31	Ground cover	-.48*	Canopy	.39*	Slope	-.24*
	Slope	-.29	Duff and litter	.41*	Ground cover	-.45*	Canopy	.36**
	Canopy	.36*	True fir seed source	-.40*	Grass	.33	Duff and litter	.50**
	Years	.35*	Undisturbed seedbed	.40*	Woody perennials	-.60**	Logs, wood, bark	-.35**
	Ground cover	.28			Duff and litter	.82**	True fir seed source	-.29**
	Duff and litter	.52**			Logs, wood, bark	-.51**	Precipitation	.33**
	Logs, wood, bark	-.49**			Undisturbed seedbed	.66**	Undisturbed seedbed	.34**
	Undisturbed seedbed	.31						
Advance true firs	Aspect	.33	Elevation	.66**	Years	.38*	Elevation	.28**
	Douglas-fir seed source	-.68**	True fir seed source	.65**	Ground cover	.32	Slope	-.18
	True fir seed source	.63**			Douglas-fir seed source	-.46*	Douglas-fir seed source	-.49**
					True fir seed source	.41*	True fir seed source	.58**
Advance incense-cedar	Elevation	-.36*	Radiation index	.41*	Radiation index	.33	Radiation index	.31**
	Slope	-.55**	Aspect	-.45*	Aspect	-.35	Aspect	-.35**
	Canopy	.30	Slope	-.41*	Canopy	-.47*	Slope	-.26*
	Years	.34*	Canopy	.35			Years	.27*
	Duff and litter	.28	Woody perennials	-.38			Duff and litter	.26*
	Undisturbed seedbed	.32	Duff and litter	.52**			Undisturbed seedbed	.23*
			Undisturbed seedbed	.46*				

1/ Degrees of freedom for the significant correlations in each stocking category are 33, 23, 25, and 85, respectively, for Applegate, Evans, Galice-Glendale, and combined data sets.

2/ Correlation coefficients with 0, 1, or 2 asterisks are significant at the 10-, 5-, and 1-percent probability levels, respectively. To determine the amount of total variation accounted for by any single independent variable, square its r-value.

Table 26—Significant associations between subsequent stocking in partial cuts and environmental variables by area

Stocking category	Environmental variable and its correlation coefficient (r) 1/ 2/							
	Applegate		Evans		Galice-Glendale		Areas combined	
Total subsequent	Duff and litter	-0.41*	Logs, wood, bark	-0.41*	Elevation	0.35	Duff and litter	-0.25*
	Undisturbed seedbed	-.41*			Undisturbed seedbed	-.32	Undisturbed seedbed	-.30**
Second-year	Canopy	-.48**	Elevation	.52**	Elevation	-.53**	Radiation index	.20
	Duff and litter	-.45**	Years	-.35	Grass	.62**		
	Undisturbed seedbed	-.38*	Woody perennials	-.39	Woody perennials	-.32		
					Precipitation	-.38*		
Douglas-fir	Canopy	-.31	Logs, wood, bark	-.35	Elevation	.34	Elevation	.22*
	Duff and litter	-.44**			Duff and litter	-.42*	Duff and litter	-.36**
	Douglas-fir seed source	.36*			Undisturbed seedbed	-.43*	Douglas-fir seed source	.25*
	Undisturbed seedbed	-.42*					Undisturbed seedbed	-.37**
True firs	Aspect	.43**	Elevation	.43*	Slope	-.32	Elevation	.28**
	Duff and litter	-.29	Ground cover	.39	Canopy	.33	Slope	-.19
	Douglas-fir seed source	-.42*	True fir seed source	.63**	Years	.38*	Grass	-.20
	True fir seed source	.65**			Ground cover	.32	Duff and litter	-.19
					Douglas-fir seed source	-.37	Douglas-fir seed source	-.31**
					True fir seed source	.53**	True fir seed source	.62**
Incense-cedar	Slope	-.37*	Aspect	-.39	Canopy	-.35	Radiation index	.25*
	Years	.48**	Slope	-.58**	Undisturbed seedbed	-.36	Aspect	-.24*
			Douglas-fir seed source	-.35			Slope	-.18
							Canopy	-.18
Sugar and western white pine			Elevation	-.55**	Ground cover	-.57**	Ground cover	-.27*
			Ground cover	-.42*	Grass	.35	Douglas-fir seed source	-.22*
			Douglas-fir seed source	-.35	Woody perennials	-.43*		
			Precipitation	-.38	Duff and litter	.42*		
					Undisturbed seedbed	.38*		

1/ Degrees of freedom for the significant correlations in each stocking category are 33, 23, 25, and 85, respectively, for Applegate, Evans, Galice-Glendale, and combined data sets.

2/ Correlation coefficients with 0, 1, or 2 asterisks are significant at the 10-, 5-, and 1-percent probability levels, respectively. To determine the amount of total variation accounted for by any single independent variable, square its r-value.

Table 27—Significant associations between total or advance stocking in clearcuts and environmental variables by area

Stocking category	Environmental variable and its correlation coefficient (r) 1/ 2/							
	Applegate		Evans		Galice-Glendale		Areas combined	
Total	Precipitation	0.59*	Precipitation	0.50	Radiation index	-0.59*	Seed source distance	0.24
					Aspect	.44		
Advance all species	Years	-.51*	Duff and litter	.48	Radiation index	-.55*	Radiation index	-.29*
	Woody perennials	-.70**	Seed source distance	.44			Duff and litter	.29*
			Undisturbed seedbed	.51*			Seed source distance	.33*
							Undisturbed seedbed	.32*
Advance Douglas-fir	Elevation	-.44			Radiation index	-.57*	Elevation	-.28
	Years	-.83**			Aspect	.44	Radiation index	-.30*
	Grass	.52*			Years	-.45	Seed source distance	.26
	Woody perennials	-.59*					Undisturbed seedbed	.24
Advance true firs	Elevation	.65**	Aspect	-.46			Elevation	.31*
			Undisturbed seedbed	.48			Duff and litter	.29*
							Precipitation	.27
Advance incense-cedar	Woody perennials	-.58*	Slope	-.63*	Years	-.56*	Slope	-.26
	Seed source distance	.72**	Grass	.59*			Woody perennials	-.30*
	Precipitation	-.55*					Precipitation	-.26

1/ Degrees of freedom for the significant correlations in each stocking category are 13, 13, 15, and 45, respectively, for Applegate, Evans, Galice-Glendale, and combined data sets.

2/ Correlation coefficients with 0, 1, or 2 asterisks are significant at the 10-, 5-, and 1-percent probability levels, respectively. To determine the amount of total variation accounted for by any single independent variable, square its r-value.

Table 28—Significant associations between subsequent stocking in clearcuts and environmental variables by area

Stocking category	Environmental variable and its correlation coefficient (r) 1/ 2/							
	Applegate		Evans		Galice-Glendale		Areas combined	
Total subsequent	Precipitation	0.56*	Logs, wood, bark	-0.50	Radiation index	-0.45		
			Undisturbed seedbed	-.46				
Second-year	Precipitation	.50						
Douglas-fir			Radiation index	-.44	Radiation index	-.45	Radiation index	-0.28
			Aspect	.49	Grass	-.62**	Aspect	.35*
					Woody perennials	.50*	Grass	-.28
					Duff and litter	-.53*	Woody perennials	.29*
							Logs, wood, bark	.25
							Precipitation	.32*
True firs	Elevation	.55*	Elevation	.46	Elevation	.64**	Elevation	.55**
			Years	-.57*	Years	.53*	Precipitation	.35*
			Seed source distance	.56*	Ground cover	-.41		
					Precipitation	.55*		
Incense-cedar	Slope	-.66**	Duff and litter	-.50	Aspect	.43	Woody perennials	-.25
	Woody perennials	-.46	Undisturbed seedbed	-.47				
	Logs, wood, bark	-.53*						
	Seed source distance	.62*						
Ponderosa pine	Aspect	-.48	Undisturbed seedbed	-.50	Elevation	-.43	Woody perennials	-.46**
	Slope	-.65**			Ground cover	.52*	Logs, wood, bark	-.33*
	Logs, wood, bark	-.57*			Grass	.96**	Seed source distance	.33*
					Woody perennials	-.90**	Precipitation	-.39**
					Duff and litter	.50*		
					Precipitation	-.61**		

1/ Degrees of freedom for the significant correlations in each stocking category are 13, 13, 15, and 45, respectively, for Applegate, Evans, Galice-Glendale, and combined data sets.

2/ Correlation coefficients with 0, 1, or 2 asterisks are significant at the 10-, 5-, and 1-percent probability levels, respectively. To determine the amount of total variation accounted for by any single independent variable, square its r-value.

Table 29—Significant associations between total or advance stocking in cutovers and environmental variables by forest type

Stocking category	Environmental variable and its correlation coefficient (r) 1/ 2/							
	Partial cuts				Clearcuts			
	Douglas-fir		Pine		Douglas-fir		Pine	
Total	Slope	-0.38**	Elevation	0.42	Precipitation	0.50**	Radiation index	-0.76*
	Canopy	.20	True fir seed source	-.42				
	Years	.28*						
	Douglas-fir seed source	-.23						
	Precipitation	.30*						
Advance all species	Elevation	-.37**	Slope	.44	Radiation index	.27	Duff and litter	.60
	Slope	-.44**			Seed source distance	.36*		
	Canopy	.39**						
	Duff and litter	.46**						
	Logs, wood, bark	-.24*						
	Douglas-fir seed source	-.28*						
	Precipitation	.37**						
	Undisturbed seedbed	.37**						
Advance Douglas-fir	Elevation	-.53**	Slope	.47	Elevation	-.30	Duff and litter	.64
	Slope	-.35**	Logs, wood, bark	-.53*	Radiation index	-.30	Undisturbed seedbed	.59
	Canopy	.47**						
	Duff and litter	.54**						
	Logs, wood, bark	-.31**						
	True fir seed source	-.29*						
	Precipitation	.32**						
	Undisturbed seedbed	.41**						
Advance true firs	Elevation	.32**	Slope	-.44	Elevation	.40*		
	Woody perennials	-.20	Ground cover	.60*				
	Douglas-fir seed source	-.46**	Douglas-fir seed source	-.62**				
	True fir seed source	.59**	True fir seed source	.57*				
Advance incense-cedar	Radiation index	.37**	Precipitation	-.44	Slope	-.28		
	Aspect	-.41**	Undisturbed seedbed	.60*	Woody perennials	-.27		
	Slope	-.26*						
	Years	.41**						
	Duff and litter	.22						

1/ Degrees of freedom for the significant correlations in each stocking category are 68 and 15 in data sets for partial cuts and 36 and 7 in data sets for clearcuts for Douglas-fir and pine types, respectively.

2/ Correlation coefficients with 0, 1, or 2 asterisks are significant at the 10-, 5-, and 1-percent probability levels, respectively. To determine the amount of total variation accounted for by any single independent variable, square its r-value.

Table 30—Significant associations between subsequent stocking in cutovers and environmental variables by forest type

Stocking category	Environmental variable and its correlation coefficient (r) 1/ 2/							
	Partial cuts				Clearcuts			
	Douglas-fir		Pine		Douglas-fir		Pine	
Total subsequent	Duff and litter	-0.33**	True fir seed source	-0.56*	Precipitation	0.48**	Radiation index	-0.79*
	Undisturbed seedbed	-.36**						
Second-year	Years	-.20	Elevation	.45			Undisturbed seedbed	.58
			Radiation index	.46				
			Aspect	-.70**				
Douglas-fir	Duff and litter	-.39**	Elevation	.42	Aspect	.35*	Elevation	.90**
	Douglas-fir seed source	.23	Slope	.50*	Grass	-.32*		
	Undisturbed seedbed	-.38**	Douglas-fir seed source	.44	Woody perennials	.35*		
					Precipitation	.50**		
True firs	Elevation	.33**	Slope	-.49*	Elevation	.43**	Elevation	.72*
	Duff and litter	-.20	Ground cover	.44			Radiation index	-.60
	Douglas-fir seed source	-.30*	Woody perennials	.44				
	True fir seed source	.61**	Logs, wood, bark	.47				
			Douglas-fir seed source	-.47				
			True fir seed source	.69**				
Incense-cedar	Radiation index	.26*	Ground cover	-.46	Woody perennials	-.33*	Logs, wood, bark	.62
	Aspect	-.21			Undisturbed seedbed	-.27	Undisturbed seedbed	.65
	Years	.27*						
Sugar and western white pine (for partial cuts)	Elevation	-.31**	Elevation	.56*	Years	.33*	Elevation	-.74*
	Slope	-.30*	Canopy	-.53*	Woody perennials	-.42**	Years	.59
	Canopy	.26*			Logs, wood, bark	-.46**	Precipitation	-.76*
Ponderosa pine (for clearcuts)	Ground cover	-.29*			Seed source distance	.29		
	Douglas-fir seed source	-.26*						
	Precipitation	.20						

1/ Degrees of freedom for the significant correlations in each stocking category are 68 and 15 in data sets for partial cuts and 36 and 7 in data sets for clearcuts for Douglas-fir and pine types, respectively.

2/ Correlation coefficients with 0, 1, or 2 asterisks are significant at the 10-, 5-, and 1-percent probability levels, respectively. To determine the amount of total variation accounted for by any single independent variable, square its r-value.

Table 31—Regressions between stocking and environmental variables for Applegate partial cuts

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	135.02	-0.47	(slope)	0.19	4/30	4.86**
		-84.93	(radiation index)	.27		
		2.04	(years)	.35		
		-.19	(Douglas-fir seed source)	.39		
Advance all species	68.59	-.56	(Douglas-fir seed source)	.27	4/30	10.56***
		-.37	(slope)	.44		
		2.84	(years)	.52		
		.37	(duff and litter)	.58		
Advance Douglas-fir	44.61	.86	(duff and litter)	.27	5/29	8.79***
		2.09	(years)	.41		
		-.55	(undisturbed seedbed)	.48		
		-.22	(Douglas-fir seed source)	.54		
		-1.95	(aspect)	.60		
Advance true firs	45.36	-.41	(Douglas-fir seed source)	.47	3/31	16.45***
		.57	(true fir seed source)	.58		
		-.37	(grass)	.61		
Advance incense-cedar	29.53	-.50	(slope)	.30	4/30	6.66***
		.34	(undisturbed seedbed)	.36		
		1.60	(years)	.41		
		-65.73	(radiation index)	.47		
Total subsequent	35.45	-.51	(duff and litter)	.17	5/29	3.61*
		-.53	(slope)	.24		
		.37	(ground cover)	.29		
		.01	(elevation)	.33		
		.23	(Douglas-fir seed source)	.38		
Second-year	9.22	-.13	(canopy)	.23	4/30	5.03**
		12.89	(radiation index)	.29		
		-.04	(Douglas-fir seed source)	.36		
		-.04	(undisturbed seedbed)	.40		
Subsequent Douglas-fir	70.12	-.48	(duff and litter)	.20	4/30	5.60**
		.35	(Douglas-fir seed source)	.30		
		-.78	(grass)	.35		
		-.34	(woody perennials)	.43		
Subsequent true firs	-1.45	.68	(true fir seed source)	.42	4/30	12.53***
		-.41	(slope)	.53		
		.01	(elevation)	.59		
		.34	(grass)	.63		
Subsequent incense-cedar	1.40	1.37	(years)	.23	3/31	5.66**
		-.14	(slope)	.29		
		.27	(logs, wood, bark)	.35		
Subsequent sugar and western white pine	-51.45	74.06	(radiation index)	.06	3/31	3.40*
		.014	(elevation)	.18		
		-.28	(slope)	.25		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

Table 32—Regressions between stocking and environmental variables for Evans partial cuts

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	176.29	1.45	(duff and litter)	0.12	7/17	2/ 2.32
		.38	(true fir seed source)	.18		
		-.90	(undisturbed seedbed)	.23		
		-.33	(ground cover)	.30		
		-141.13	(radiation index)	.35		
		-2.59	(aspect)	.43		
		-.24	(Douglas-fir seed source)	.49		
Advance all species	33.98	.68	(undisturbed seedbed)	.22	6/18	8.95***
		-.53	(woody perennials)	.34		
		-.63	(ground cover)	.44		
		.96	(precipitation)	.49		
		-.82	(slope)	.57		
		.74	(Douglas-fir seed source)	.75		
Advance Douglas-fir	43.42	-.55	(ground cover)	.23	3/21	8.88***
		.71	(duff and litter)	.43		
		-1.75	(years)	.56		
Advance true firs	-123.05	.019	(elevation)	.43	4/20	12.23***
		.84	(true fir seed source)	.57		
		128.99	(radiation index)	.65		
		2.16	(aspect)	.71		
Advance incense-cedar	34.15	.82	(duff and litter)	.27	4/20	5.85**
		-.62	(woody perennials)	.39		
		-.72	(slope)	.48		
		.50	(Douglas-fir seed source)	.54		
Total subsequent	239.66	-2.13	(logs, wood, bark)	.17	5/19	5.99**
		-304.76	(radiation index)	.26		
		.82	(canopy)	.39		
		-.61	(Douglas-fir seed source)	.50		
		-3.42	(aspect)	.61		
Second-year	-31.36	.009	(elevation)	.27	3/21	6.31**
		33.39	(radiation index)	.41		
		-.16	(ground cover)	.47		
Subsequent Douglas-fir	67.04	-1.86	(logs, wood, bark)	.13	5/19	5.39**
		-195.69	(radiation index)	.25		
		1.58	(canopy)	.41		
		-.74	(duff and litter)	.50		
		.014	(elevation)	.59		
Subsequent true firs	7.05	1.13	(true fir seed source)	.39	5/19	5.81**
		-.66	(grass)	.47		
		.38	(ground cover)	.52		
		-.34	(canopy)	.57		
		-.56	(logs, wood, bark)	.60		
Subsequent incense-cedar	32.04	-.43	(slope)	.33	4/20	5.44**
		-.89	(years)	.41		
		-1.00	(aspect)	.46		
		.21	(woody perennials)	.52		
Subsequent sugar and western white pine	52.44	.0004	(elevation)	.30	6/18	5.84**
		-.37	(Douglas-fir seed source)	.42		
		-.49	(ground cover)	.49		
		.92	(years)	.56		
		-.46	(precipitation)	.60		
		.22	(slope)	.66		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

2/ Significant at the 10-percent level.

Table 33—Regressions between stocking and environmental variables for Galice-Glendale partial cuts

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	67.53	-0.63	(logs, wood, bark)	0.12	3/23	4.58*
		.36	(precipitation)	.23		
		1.06	(grass)	.37		
Advance all species	71.37	.56	(duff and litter)	.57	3/23	21.83***
		-.60	(woody perennials)	.66		
		.44	(canopy)	.74		
Advance Douglas-fir	17.90	1.05	(duff and litter)	.67	4/22	36.12***
		-.73	(woody perennials)	.79		
		.29	(Douglas-fir seed source)	.83		
		78.81	(radiation index)	.87		
Advance true firs	-2.99	-.35	(Douglas-fir seed source)	.21	4/22	4.98**
		.45	(ground cover)	.35		
		.71	(true fir seed source)	.43		
		1.22	(aspect)	.48		
Advance incense-cedar	-15.44	-.21	(canopy)	.22	6/20	4.57**
		-.88	(aspect)	.33		
		.14	(Douglas-fir seed source)	.38		
		.005	(elevation)	.43		
		.21	(undisturbed seedbed)	.53		
		.10	(ground cover)	.58		
Total subsequent	58.09	.016	(elevation)	.12	4/22	3.73*
		-.76	(woody perennials)	.22		
		-.38	(undisturbed seedbed)	.33		
		99.17	(radiation index)	.40		
Second-year	-22.09	.86	(grass)	.39	4/22	7.96***
		60.58	(radiation index)	.47		
		-.17	(precipitation)	.53		
		.14	(undisturbed seedbed)	.59		
Subsequent Douglas-fir	20.83	-.29	(undisturbed seedbed)	.18	6/20	3.55*
		.016	(elevation)	.24		
		.80	(Douglas-fir seed source)	.30		
		.63	(precipitation)	.36		
		-.84	(woody perennials)	.43		
		-2.76	(aspect)	.52		
Subsequent true firs	-28.52	.71	(true fir seed source)	.28	5/21	6.00**
		1.53	(years)	.42		
		.17	(ground cover)	.51		
		.20	(canopy)	.55		
		.28	(logs, wood, bark)	.59		
Subsequent incense-cedar	-32.41	-.23	(undisturbed seedbed)	.13	3/23	3.43*
		.41	(slope)	.19		
		81.50	(radiation index)	.31		
Subsequent sugar and western white pine	41.06	-.57	(ground cover)	.33	4/22	6.53**
		-.24	(slope)	.41		
		1.53	(years)	.46		
		.79	(grass)	.54		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

Table 34—Regressions between stocking and environmental variables for combined data from Applegate, Evans, and Galice-Glendale partial cuts.

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	85.67	-0.27	(slope)	0.14	3/83	8.26***
		.24	(precipitation)	.19		
		-.41	(logs, wood, bark)	.23		
Advance all species	23.25	.62	(duff and litter)	.19	3/83	16.07***
		-.37	(slope)	.31		
		.37	(precipitation)	.37		
Advance Douglas-fir	36.96	.51	(duff and litter)	.25	5/81	15.41***
		.46	(precipitation)	.36		
		-.011	(elevation)	.44		
		-.58	(logs, wood, bark)	.47		
		-.96	(years)	.49		
Advance true firs	18.20	.78	(true fir seed source)	.34	3/83	22.86***
		-.28	(Douglas-fir seed source)	.42		
		.21	(ground cover)	.45		
Advance incense-cedar	42.33	-1.76	(aspect)	.12	6/80	6.53***
		.36	(undisturbed seedbed)	.17		
		1.18	(years)	.22		
		-.31	(precipitation)	.25		
		-.32	(slope)	.30		
		-.27	(canopy)	.33		
Total subsequent	98.92	-.41	(undisturbed seedbed)	.09	4/82	4.44**
		-.32	(woody perennials)	.11		
		-.60	(grass)	.16		
		.87	(years)	.18		
Second-year	-4.52	24.73	(radiation index)	.04	3/83	3.55*
		-.45	(years)	.09		
		.12	(grass)	.11		
Subsequent Douglas-fir	52.11	-.43	(undisturbed seedbed)	.13	5/81	5.81***
		.27	(Douglas-fir seed source)	.17		
		.006	(elevation)	.21		
		-.71	(grass)	.24		
		-.24	(woody perennials)	.26		
Subsequent true firs	2.04	.81	(true fir seed source)	.38	4/82	18.94***
		-.22	(slope)	.42		
		.005	(elevation)	.45		
		-.30	(grass)	.48		
Subsequent incense-cedar	6.52	39.57	(radiation index)	.06	6/80	3.83**
		-.18	(canopy)	.11		
		-.18	(precipitation)	.14		
		-.16	(slope)	.18		
		-.21	(grass)	.20		
		.003	(elevation)	.22		
Subsequent sugar and western white pine	43.52	-.30	(ground cover)	.07	4/82	4.47**
		-.15	(slope)	.13		
		-.16	(Douglas-fir seed source)	.15		
		-.27	(true fir seed source)	.18		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

Table 35—Regressions between stocking and environmental variables for Applegate clearcuts

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	66.24	1.20	(precipitation)	0.35	4/10	7.92**
		1.55	(seed source distance)	.51		
		-1.05	(ground cover)	.63		
		.87	(duff and litter)	.76		
Advance all species	34.92	-.88	(woody perennials)	.49	4/10	12.65***
		.40	(undisturbed seedbed)	.62		
		.008	(elevation)	.77		
		.37	(precipitation)	.84		
Advance Douglas-fir	47.88	-2.16	(years)	.70	4/10	21.67***
		.14	(grass)	.79		
		-.003	(elevation)	.84		
		-32.84	(radiation index)	.90		
Advance true firs	-12.87	.008	(elevation)	.42	2/12	7.25**
		-1.05	(aspect)	.55		
Advance incense-cedar	27.95	1.08	(seed source distance)	.52	4/10	14.18***
		-.37	(precipitation)	.65		
		-.24	(undisturbed seedbed)	.77		
		-.96	(years)	.85		
Total subsequent	4.87	1.35	(precipitation)	.31	2/12	5.04*
		1.22	(seed source distance)	.46		
Second-year	-0.89	.13	(precipitation)	.25	5/9	12.80***
		.11	(duff and litter)	.43		
		-.15	(logs, wood, bark)	.62		
		-.34	(years)	.80		
		.13	(grass)	.88		
Subsequent Douglas-fir	-85.52	5.26	(aspect)	.17	3/11	4.53*
		1.45	(precipitation)	.35		
		.68	(undisturbed seedbed)	.55		
Subsequent true firs	-71.97	.015	(elevation)	.30	3/11	3.62*
		.69	(precipitation)	.39		
		.93	(seed source distance)	.50		
Subsequent incense-cedar	26.24	-.21	(slope)	.44	4/10	10.43**
		-.20	(precipitation)	.62		
		-.42	(logs, wood, bark)	.68		
		.74	(seed source distance)	.81		
Subsequent ponderosa pine	86.48	-.44	(slope)	.42	4/10	9.54**
		-1.85	(logs, wood, bark)	.53		
		-3.52	(aspect)	.68		
		.70	(undisturbed seedbed)	.79		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

Table 36—Regressions between stocking and environmental variables for Evans clearcuts

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	99.48	1.60	(precipitation)	0.25	5/9	7.66**
		1.73	(aspect)	.42		
		-1.20	(logs, wood, bark)	.62		
		-164.99	(radiation index)	.71		
		-.44	(slope)	.81		
Advance all species	90.81	.73	(undisturbed seedbed)	.26	4/10	3.94*
		-4.09	(aspect)	.42		
		-.33	(woody perennials)	.52		
		-.41	(slope)	.61		
Advance Douglas-fir	96.65	-.93	(slope)	.18	6/8	2/ 3.45
		1.12	(duff and litter)	.27		
		1.20	(precipitation)	.39		
		-.013	(elevation)	.52		
		-129.99	(radiation index)	.59		
		-.74	(undisturbed seedbed)	.72		
Advance true firs	27.17	.39	(undisturbed seedbed)	.23	4/10	6.83**
		-2.74	(aspect)	.55		
		-.16	(woody perennials)	.68		
		.004	(elevation)	.73		
Advance incense-cedar	31.98	-.20	(slope)	.39	3/11	6.30**
		-35.63	(radiation index)	.56		
		-.50	(aspect)	.63		
Total subsequent	-39.39	-1.51	(logs, wood, bark)	.25	3/11	8.19**
		6.30	(aspect)	.40		
		1.52	(precipitation)	.69		
Subsequent Douglas-fir	-165.21	5.88	(aspect)	.24	4/10	8.12**
		1.36	(precipitation)	.50		
		1.01	(ground cover)	.65		
		.011	(elevation)	.76		
Subsequent true firs	14.74	-2.52	(years)	.32	4/10	8.87**
		-15.92	(radiation index)	.57		
		.26	(slope)	.68		
		1.30	(aspect)	.78		
Subsequent incense-cedar	-5.02	-.69	(duff and litter)	.25	2/12	4.03*
		.013	(elevation)	.40		
Subsequent ponderosa pine	159.18	-1.27	(undisturbed seedbed)	.25	3/11	5.42*
		-214.20	(radiation index)	.41		
		.46	(seed source distance)	.60		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

2/ Significant at the 10-percent level.

Table 37—Regressions between stocking and environmental variables for Galice-Glendale clearcuts

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	156.03	-141.99	(radiation index)	0.35	2/14	6.02*
		-.45	(slope)	.46		
Advance all species	199.22	-308.00	(radiation index)	.30	2/14	4.23*
		-4.69	(aspect)	.38		
Advance Douglas-fir	67.47	-106.37	(radiation index)	.33	4/12	6.00**
		-4.73	(years)	.50		
		.39	(duff and litter)	.55		
		.53	(precipitation)	.67		
Advance true firs	-26.09	.56	(precipitation)	.15	3/13	2/ 2.78
		.41	(duff and litter)	.31		
		-.41	(slope)	.39		
Advance incense-cedar	5.99	-1.15	(years)	.31	4/12	4.01*
		.08	(duff and litter)	.38		
		.10	(precipitation)	.51		
		-.07	(logs, wood, bark)	.57		
Total subsequent	141.52	-105.26	(radiation index)	.20	2/14	4.45*
		-.56	(slope)	.39		
Second-year	-15.91	.29	(aspect)	.15	3/13	4.23*
		.001	(elevation)	.28		
		.12	(ground cover)	.49		
Subsequent Douglas-fir	289.27	-2.67	(grass)	.38	4/12	6.61**
		-2.87	(years)	.52		
		-1.61	(woody perennials)	.61		
		-81.56	(radiation index)	.69		
Subsequent true firs	-13.85	.011	(elevation)	.41	3/13	5.82**
		-57.10	(radiation index)	.50		
		1.44	(years)	.57		
Subsequent incense-cedar	-124.60	2.62	(aspect)	.19	3/13	3.77*
		.011	(elevation)	.28		
		.98	(ground cover)	.47		
Subsequent ponderosa pine	.08	1.24	(grass)	.93	1/15	200.45***

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

2/ Significant at the 10-percent level.

Table 38—Regressions between stocking and environmental variables for combined data from Applegate, Evans, and Galice-Glendale clearcuts

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	155.62	0.15	(seed source distance)	0.06	6/40	2.88*
		-93.66	(radiation index)	.09		
		-.27	(slope)	.16		
		.26	(precipitation)	.19		
		-.49	(woody perennials)	.25		
		-.56	(grass)	.30		
Advance all species	133.38	.25	(seed source distance)	.11	7/39	4.01**
		.27	(undisturbed seedbed)	.17		
		.38	(precipitation)	.21		
		-176.57	(radiation index)	.27		
		-1.60	(years)	.33		
		-2.91	(aspect)	.38		
		-.29	(woody perennials)	.42		
Advance Douglas-fir	70.09	-84.50	(radiation index)	.09	5/41	6.08***
		-.007	(elevation)	.19		
		.29	(precipitation)	.26		
		-2.14	(years)	.36		
		.24	(duff and litter)	.43		
Advance true firs	84.76	.004	(elevation)	.09	7/39	4.98***
		.32	(duff and litter)	.20		
		.21	(precipitation)	.26		
		-.36	(ground cover)	.31		
		-2.76	(aspect)	.33		
		-107.49	(radiation index)	.42		
		-.22	(slope)	.47		
Advance incense-cedar	11.02	-.11	(woody perennials)	.09	5/41	3.14*
		-.09	(slope)	.14		
		-.08	(precipitation)	.19		
		.15	(ground cover)	.24		
		-.15	(grass)	.28		
Total subsequent	79.05	.29	(precipitation)	.04	4/42	2/ 2.19
		1.51	(aspect)	.08		
		-.45	(woody perennials)	.13		
		-.52	(grass)	.17		
Second-year	1.03	.02	(precipitation)	.03	3/43	3/ 1.51
		.02	(duff and litter)	.06		
		-.03	(ground cover)	.10		
Subsequent Douglas-fir	5.01	3.85	(aspect)	.12	3/43	7.56***
		.53	(precipitation)	.28		
		-1.86	(years)	.35		
Subsequent true firs	-20.76	.01	(elevation)	.30	4/42	9.13***
		.23	(precipitation)	.38		
		-37.43	(radiation index)	.43		
		.12	(undisturbed seedbed)	.47		
Subsequent incense-cedar	36.21	-.52	(woody perennials)	.06	3/43	3.01*
		-.74	(grass)	.13		
		.30	(ground cover)	.17		
Subsequent ponderosa pine	84.19	-.47	(woody perennials)	.21	4/42	8.25***
		.43	(seed source distance)	.32		
		-.71	(logs, wood, bark)	.38		
		-.33	(precipitation)	.44		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

2/ Significant at the 10-percent level.

3/ Significant at the 25-percent level.

Table 39—Regressions between stocking and environmental variables for partial cuts in the Douglas-fir type

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	101.22	-0.33	(slope)	0.15	6/63	5.55***
		1.58	(years)	.19		
		.48	(precipitation)	.25		
		-48.17	(radiation index)	.29		
		-.36	(logs, wood, bark)	.32		
		-.18	(woody perennials)	.35		
Advance all species	36.75	.72	(duff and litter)	.21	4/65	18.23***
		-.57	(slope)	.43		
		.67	(precipitation)	.50		
		-.26	(woody perennials)	.53		
Advance Douglas-fir	54.88	.64	(duff and litter)	.29	5/64	18.07***
		-.012	(elevation)	.47		
		.44	(precipitation)	.55		
		-.26	(slope)	.56		
		-46.16	(radiation index)	.59		
Advance true firs	16.97	.62	(true fir seed source)	.34	4/65	12.92***
		-.21	(Douglas-fir seed source)	.39		
		-.24	(slope)	.41		
		.007	(elevation)	.44		
Advance incense-cedar	49.80	2.26	(years)	.17	6/63	9.00***
		-1.89	(aspect)	.28		
		-.31	(woody perennials)	.37		
		-.24	(slope)	.39		
		.31	(undisturbed seedbed)	.42		
		-.35	(canopy)	.46		
Total subsequent	96.68	-.46	(undisturbed seedbed)	.13	4/65	4.22**
		-.31	(woody perennials)	.15		
		1.10	(years)	.18		
		-.47	(grass)	.21		
Second-year	-4.01	-.58	(years)	.04	3/66	3.72*
		24.99	(radiation index)	.10		
		.18	(grass)	.14		
Subsequent Douglas-fir	66.67	-.50	(duff and litter)	.15	1/68	11.86**
Subsequent true firs	1.70	.78	(true fir seed source)	.37	4/65	14.44***
		-.35	(grass)	.41		
		-.25	(slope)	.44		
		.006	(elevation)	.47		
Subsequent incense-cedar	-1.35	.88	(years)	.07	3/66	4.98**
		-.20	(canopy)	.13		
		28.42	(radiation index)	.18		
Subsequent sugar and western white pine	29.63	-.002	(elevation)	.09	4/65	5.66***
		-.30	(ground cover)	.18		
		-.19	(slope)	.23		
		.18	(canopy)	.26		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

Table 40—Regressions between stocking and environmental variables for partial cuts in the pine types

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	92.17	0.018	(elevation)	0.18	6/10	9.10**
		-2.21	(years)	.47		
		-.95	(logs, wood, bark)	.57		
		.29	(woody perennials)	.68		
		-74.71	(radiation index)	.78		
		-.28	(canopy)	.85		
Advance all species	10.90	.97	(slope)	.19	3/13	2/ 3.02
		-.96	(grass)	.32		
		.49	(duff and litter)	.41		
Advance Douglas-fir	103.60	-1.56	(logs, wood, bark)	.28	6/10	4.92*
		-.43	(ground cover)	.46		
		.25	(precipitation)	.55		
		-3.37	(years)	.60		
		-.43	(Douglas-fir seed source)	.67		
		.67	(slope)	.75		
Advance true firs	37.46	-.36	(Douglas-fir seed source)	.39	5/11	12.93***
		.41	(true fir seed source)	.61		
		.54	(ground cover)	.75		
		-79.62	(radiation index)	.81		
		.69	(logs, wood, bark)	.85		
Advance incense-cedar	-133.97	1.72	(undisturbed seedbed)	.36	4/12	10.06***
		-.54	(precipitation)	.49		
		.82	(woody perennials)	.66		
		.76	(slope)	.77		
Total subsequent	59.76	-.86	(true fir seed source)	.31	3/13	5.57*
		-.72	(grass)	.46		
		.17	(Douglas-fir seed source)	.56		
Second-year	22.36	-1.28	(aspect)	.49	3/13	13.44***
		-.11	(precipitation)	.63		
		-.23	(grass)	.76		
Subsequent Douglas-fir	-38.76	.47	(slope)	.25	4/12	9.21**
		-.79	(grass)	.40		
		.41	(Douglas-fir seed source)	.60		
		.016	(elevation)	.75		
Subsequent true firs	-40.96	1.11	(true fir seed source)	.48	5/11	12.40***
		.36	(ground cover)	.62		
		.42	(undisturbed seedbed)	.72		
		.01	(elevation)	.80		
		-55.76	(radiation index)	.85		
Subsequent incense-cedar	205.97	-.18	(ground cover)	.21	6/10	5.16*
		-4.85	(aspect)	.34		
		-.38	(precipitation)	.43		
		-.57	(grass)	.55		
		-.76	(canopy)	.68		
		-162.37	(radiation index)	.76		
Subsequent sugar and western white pine	27.48	.015	(elevation)	.31	3/13	5.45*
		-.76	(canopy)	.47		
		-.45	(duff and litter)	.56		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

2/ Significant at the 10-percent level.

Table 41—Regressions between stocking and environmental variables for clearcuts in the Douglas-fir type

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	84.90	0.68	(precipitation)	0.25	4/33	6.86***
		.20	(seed source distance)	.32		
		-.47	(woody perennials)	.40		
		-.51	(grass)	.45		
Advance all species	51.87	.26	(seed source distance)	.13	5/32	3.54*
		-2.45	(years)	.20		
		-69.36	(radiation index)	.26		
		.30	(duff and litter)	.30		
		.28	(precipitation)	.36		
Advance Douglas-fir	73.32	-.007	(elevation)	.09	5/32	4.24**
		-86.39	(radiation index)	.20		
		-2.17	(years)	.30		
		.27	(precipitation)	.34		
		.24	(duff and litter)	.40		
Advance true firs	-10.26	.005	(elevation)	.16	2/35	5.60**
		.12	(seed source distance)	.24		
Advance incense-cedar	29.64	-.16	(slope)	.08	4/33	2.98*
		-.08	(precipitation)	.17		
		-24.10	(radiation index)	.22		
		-.08	(woody perennials)	.27		
Total subsequent	64.68	.70	(precipitation)	.23	4/33	5.47**
		-.49	(woody perennials)	.30		
		-.56	(grass)	.35		
		1.58	(years)	.40		
Second-year	15.55	-.07	(ground cover)	.07	7/30	2/ 2.23
		-.05	(slope)	.11		
		.03	(duff and litter)	.14		
		-.02	(seed source distance)	.18		
		-12.29	(radiation index)	.22		
		-.21	(aspect)	.29		
		-.0005	(elevation)	.34		
Subsequent Douglas-fir	-27.77	.84	(precipiation)	.25	2/35	12.42***
		3.90	(aspect)	.42		
Subsequent true firs	-12.19	.005	(elevation)	.18	2/35	5.58**
		.11	(seed source distance)	.24		
Subsequent incense-cedar	50.05	-.47	(woody perennials)	.11	2/35	4.35*
		-.53	(grass)	.20		
Subsequent ponderosa pine	74.38	-.85	(logs, wood, bark)	.21	3/34	7.11***
		.41	(seed source distance)	.30		
		-.50	(woody perennials)	.39		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

2/ Significant at the 10-percent level.

Table 42—Regressions between stocking and environmental variables for clearcuts in the pine types

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
Total	270.47	-406.61	(radiation index)	0.58	3/5	25.17**
		-6.71	(aspect)	.78		
		.012	(elevation)	.94		
Advance all species	-0.69	.69	(duff and litter)	.36	1/7	2/ 3.90
Advance Douglas-fir	-0.89	.33	(duff and litter)	.41	1/7	2/ 4.89
Advance true firs	-1.99	.62	(duff and litter)	.31	1/7	3/ 3.19
Total subsequent	253.89	-386.11	(radiation index)	.62	3/5	16.77**
		-5.94	(aspect)	.77		
		.012	(elevation)	.91		
Second-year	-16.04	.02	(undisturbed seedbed)	.33	3/5	5.97*
		.16	(ground cover)	.44		
		.50	(aspect)	.78		
Subsequent Douglas-fir	-93.92	.028	(elevation)	.81	3/5	42.90***
		3.24	(years)	.91		
		-1.21	(grass)	.96		
Subsequent true firs	-73.89	.025	(elevation)	.52	2/6	8.26*
		.48	(duff and litter)	.73		
Subsequent incense-cedar	-3.11	.45	(undisturbed seedbed)	.42	1/7	2/ 5.05
Subsequent ponderosa pine	-7.39	-.27	(precipitation)	.57	2/6	25.95**
		2.29	(years)	.90		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

2/ Significant at the 10-percent level.

3/ Significant at the 12-percent level.

Table 43—Prediction equations for subsequent stocking in partial cuts by forest type

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
			DOUGLAS-FIR TYPE			
Total	76.93	-0.45	(undisturbed seedbed)	0.13	1/68	10.13**
Second-year	-3.46	16.69	(radiation index)	.04	1/68	2/ 2.51
Douglas-fir	49.71	-.46	(duff and litter)	.15	2/67	6.99**
		.19	(Douglas-fir seed source)	.17		
True firs	.88	.77	(true fir seed source)	.37	3/66	17.14***
		-.27	(slope)	.41		
		.006	(elevation)	.44		
Incense-cedar	3.18	39.11	(radiation index)	.07	3/66	3.66*
		-.15	(canopy)	.11		
		-.13	(precipitation)	.14		
Sugar and western white pine	41.63	-.007	(elevation)	.09	2/67	7.13**
		-.19	(Douglas-fir seed source)	.18		
			PINE TYPES			
Total	68.34	-.81	(true fir seed source)	.31	1/15	6.75*
Second-year	43.86	-1.83	(aspect)	.49	3/13	9.24**
		-.08	(precipitation)	.63		
		-40.97	(radiation index)	.68		
Douglas-fir	-43.32	.26	(slope)	.25	3/13	7.25**
		.39	(Douglas-fir seed source)	.39		
		.019	(elevation)	.63		
True firs	41.11	.28	(true fir seed source)	.48	5/11	15.36***
		-.33	(Douglas-fir seed source)	.61		
		-81.28	(radiation index)	.72		
		.43	(canopy)	.81		
		.61	(logs, wood, bark)	.87		
Incense-cedar	238.58	-.90	(canopy)	.13	4/12	5.83**
		-5.81	(aspect)	.27		
		-.34	(precipitation)	.49		
		-228.96	(radiation index)	.66		
Sugar and western white pine	27.48	.015	(elevation)	.31	3/13	5.45*
		-.76	(canopy)	.47		
		-.45	(duff and litter)	.56		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

2/ Significant at the 12-percent level.

Table 44—Prediction equations for subsequent stocking in clearcuts by forest type

Stocking	= constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
	Regression formula			Statistical values		
			DOUGLAS-FIR TYPE			
Total	47.77	0.60	(precipitation)	0.23	2/35	6.59**
		-.36	(logs, wood, bark)	.27		
Douglas-fir	-27.77	.84	(precipitation)	.25	2/35	12.42***
		3.90	(aspect)	.42		
True firs	-12.19	.005	(elevation)	.18	2/35	5.58**
		.11	(seed source distance)	.24		
Incense-cedar	13.98	-.24	(undisturbed seedbed)	.07	2/35	2/ 2.77
		.20	(seed source distance)	.14		
Ponderosa pine	54.45	-1.09	(logs, wood, bark)	.21	3/34	5.97**
		.38	(seed source distance)	.30		
		-.36	(precipitation)	.35		
			PINE TYPES			
Total	253.89	-386.11	(radiation index)	.62	3/5	16.77**
		-5.94	(aspect)	.77		
		.012	(elevation)	.91		
Second-year	-21.65	.06	(undisturbed seedbed)	.33	3/5	3/ 3.26
		.76	(aspect)	.39		
		30.68	(radiation index)	.66		
Douglas-fir	-35.09	.023	(elevation)	.81	2/6	25.34**
		.24	(duff and litter)	.89		
True firs	-73.89	.025	(elevation)	.52	2/6	8.26*
		.48	(duff and litter)	.73		
Incense-cedar	-4.33	1.00	(undisturbed seedbed)	.42	2/6	3/ 3.32
		-.69	(duff and litter)	.53		
Ponderosa pine	75.59	-.18	(precipitation)	.57	4/4	25.39**
		-.01	(elevation)	.84		
		-34.97	(radiation index)	.91		
		-.15	(slope)	.96		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

2/ Significant at the 10-percent level.

3/ Significant at the 12-percent level.

Table 45—Prediction equations for subsequent stocking in partial cuts by geographic area

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
APPLEGATE						
Total	48.02	-0.41	(duff and litter)	0.17	4/30	3.88*
		-.51	(slope)	.24		
		.25	(Douglas-fir seed source)	.28		
		.01	(elevation)	.34		
Second-year	9.22	-.13	(canopy)	.23	4/30	5.03**
		12.89	(radiation index)	.29		
		-.04	(Douglas-fir seed source)	.36		
		-.04	(undisturbed seedbed)	.40		
Douglas-fir	62.69	-.46	(duff and litter)	.20	3/31	5.28**
		.34	(Douglas-fir seed source)	.30		
		-55.98	(radiation index)	.34		
True firs	-15.73	.60	(true fir seed source)	.42	4/30	12.14***
		-.45	(slope)	.53		
		.009	(elevation)	.59		
		1.45	(aspect)	.62		
Incense-cedar	12.63	-.19	(slope)	.14	2/32	3.70*
		.24	(logs, wood, bark)	.19		
Sugar and western white pine	-51.45	74.06	(radiation index)	.06	3/31	3.40*
		.014	(elevation)	.18		
		-.28	(slope)	.25		
EVANS						
Total	239.66	-2.13	(logs, wood, bark)	.17	5/19	5.99**
		-304.76	(radiation index)	.26		
		.82	(canopy)	.39		
		-.61	(Douglas-fir seed source)	.50		
		-3.42	(aspect)	.61		
Second-year	-38.33	.01	(elevation)	.27	3/21	5.99**
		32.33	(radiation index)	.41		
		-.19	(true fir seed source)	.46		
Douglas-fir	67.04	-1.86	(logs, wood, bark)	.13	5/19	5.39**
		-195.69	(radiation index)	.25		
		1.58	(canopy)	.41		
		-.74	(duff and litter)	.50		
		.014	(elevation)	.59		
True firs	11.66	1.13	(true fir seed source)	.39	4/20	5.88**
		-57.19	(radiation index)	.43		
		-.96	(logs, wood, bark)	.50		
		.009	(elevation)	.54		
Incense-cedar	35.59	-.36	(slope)	.33	2/22	6.90**
		-.84	(aspect)	.39		
Sugar and western white pine	49.74	-.01	(elevation)	.30	2/22	7.85**
		-.21	(Douglas-fir seed source)	.42		

See footnotes at end of table.

Table 45—Prediction equations for subsequent stocking in partial cuts by geographic area (continued)

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
			GALICE-GLENDALE			
Total	42.89	0.012	(elevation)	.12	2/24	2/ 2.65
		-.31	(undisturbed seedbed)	.18		
Second-year	28.31	-.009	(elevation)	.29	1/25	10.02**
Douglas-fir	-38.47	-.29	(undisturbed seedbed)	.18	4/22	3.07*
		.01	(elevation)	.24		
		.54	(Douglas-fir seed source)	.30		
		.49	(precipitation)	.36		
True firs	15.55	.44	(true fir seed source)	.28	4/22	5.16**
		.32	(canopy)	.34		
		-.21	(Douglas-fir seed source)	.39		
		-.24	(duff and litter)	.48		
Incense-cedar	-32.41	-.23	(undisturbed seedbed)	.13	3/23	3.43*
		.41	(slope)	.19		
		81.50	(radiation index)	.31		
Sugar and western white pine	4.78	.37	(duff and litter)	.18	2/24	3.45*
		-.22	(slope)	.22		
			AREAS COMBINED			
Total	65.32	-.36	(undisturbed seedbed)	.09	3/83	4.66**
		-.25	(slope)	.11		
		.007	(elevation)	.14		
Second-year	-4.17	17.72	(radiation index)	.04	1/85	2/ 3.64
Douglas-fir	26.92	-.40	(undisturbed seedbed)	.13	3/83	7.42***
		.24	(Douglas-fir seed source)	.17		
		.008	(elevation)	.21		
True firs	1.24	.81	(true fir seed source)	.38	3/83	23.04***
		-.25	(slope)	.42		
		.005	(elevation)	.45		
Incense-cedar	15.15	36.93	(radiation index)	.06	4/82	4.36**
		-.22	(canopy)	.11		
		-.15	(precipitation)	.14		
		-.14	(slope)	.18		
Sugar and western white pine	25.53	-.21	(Douglas-fir seed source)	.05	2/84	3.93*
		-.29	(true fir seed source)	.09		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

2/ Significant at the 10-percent level.

Table 46—Prediction equations for subsequent stocking in clearcuts by geographic area

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
			APPLEGATE			
Total	-27.69	1.59	(precipitation)	0.31	3/11	4.12*
		1.36	(seed source distance)	.46		
		2.02	(aspect)	.53		
Second-year	-4.53	.14	(precipitation)	.25	3/11	5.86*
		.11	(duff and litter)	.43		
		-.09	(logs, wood, bark)	.62		
Douglas-fir	-85.52	5.26	(aspect)	.17	3/11	4.53*
		1.45	(precipitation)	.35		
		.68	(undisturbed seedbed)	.55		
True firs	-71.97	.015	(elevation)	.30	3/11	3.62*
		.69	(precipitation)	.39		
		.93	(seed source distance)	.50		
Incense-cedar	26.24	-.21	(slope)	.44	4/10	10.43**
		-.20	(precipitation)	.62		
		-.42	(logs, wood, bark)	.68		
		.74	(seed source distance)	.81		
Ponderosa pine	86.48	-.44	(slope)	.42	4/10	9.54**
		-1.85	(logs, wood, bark)	.53		
		-3.52	(aspect)	.68		
		.70	(undisturbed seedbed)	.79		
			EVANS			
Total	-39.39	-1.51	(logs, wood, bark)	.25	3/11	8.19**
		6.30	(aspect)	.40		
		1.52	(precipitation)	.69		
Douglas-fir	-100.24	6.57	(aspect)	.24	3/11	6.17*
		1.14	(precipitation)	.50		
		.012	(elevation)	.63		
True firs	18.10	.15	(seed source distance)	.31	4/10	7.13**
		.004	(elevation)	.45		
		-.23	(duff and litter)	.54		
		-54.46	(radiation index)	.74		
Incense-cedar	-5.02	-.69	(duff and litter)	.25	2/12	4.03*
		.013	(elevation)	.40		
Ponderosa pine	159.18	-1.27	(undisturbed seedbed)	.25	3/11	5.42*
		-214.20	(radiation index)	.41		
		.46	(seed source distance)	.60		

See footnotes at end of table.

Table 46—Prediction equations for subsequent stocking in clearcuts by geographic area (continued)

Regression formula				Statistical values		
Stocking =	constant	±	environmental variable	Cumulative R^2	Degrees of freedom	F-ratio 1/
			GALICE-GLENDALE			
Total	141.52	-105.26	(radiation index)	.20	2/14	4.45*
		-.56	(slope)	.39		
Second-year	-3.61	.20	(aspect)	.15	2/14	2/ 2.70
		.001	(elevation)	.28		
Douglas-fir	125.00	-.91	(duff and litter)	.28	3/13	5.86**
		-132.54	(radiation index)	.53		
		.38	(undisturbed seedbed)	.57		
True firs	-6.55	.014	(elevation)	.41	2/14	6.94**
		-54.98	(radiation index)	.50		
Incense-cedar	-30.48	1.67	(aspect)	.19	3/13	2/ 2.50
		.006	(elevation)	.28		
		.15	(undisturbed seedbed)	.37		
Ponderosa pine	11.39	-.47	(precipitation)	.38	3/13	6.67**
		.27	(duff and litter)	.51		
		60.74	(radiation index)	.61		
			AREAS COMBINED			
Total	42.33	.22	(precipitation)	.04	2/44	3/ 2.02
		1.56	(aspect)	.08		
Second-year	-.17	.01	(precipitation)	.03	1/45	4/ 1.52
Douglas-fir	-9.56	3.52	(aspect)	.12	4/42	6.30***
		.46	(precipitation)	.28		
		.45	(logs, wood, bark)	.33		
		-.26	(duff and litter)	.38		
True firs	-20.76	.01	(elevation)	.30	4/42	9.13***
		.23	(precipitation)	.38		
		-37.43	(radiation index)	.43		
		.12	(undisturbed seedbed)	.47		
Incense-cedar	7.62	.15	(seed source distance)	.03	1/45	4/ 1.48
Ponderosa pine	54.19	-.46	(precipitation)	.15	3/43	8.59***
		-.90	(logs, wood, bark)	.28		
		.43	(seed source distance)	.37		

1/ 1 asterisk denotes significance of the regression F-ratio at the 5-percent probability level; 2 asterisks, 1-percent; and 3, 0.1-percent.

2/ Significant near the 10-percent level.

3/ Significant at the 15-percent level.

4/ Significant at the 23-percent level.

Stein, William I. Regeneration outlook on BLM lands in the Siskiyou Mountains. Res. Pap. PNW-349. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; **1986.** 104 p.

A survey of timberland cut over from 1956 to 1971 in the Applegate, Evans, and Galice-Glendale areas of southwestern Oregon showed that both partial cuts and clearcuts were well stocked with a combination of regeneration that started before and after harvest cutting. Advance regeneration was a major stocking component in partial cuts. Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) was the predominant species of advance and subsequent regeneration in both partial cuts and clearcuts. Stocking differed significantly by forest type, soil series, soil origin, soil depth, and stream drainage and correlated with an array of environmental variables. Regression equations describe present stocking patterns, and other equations predict future stocking based on variables that can be observed or specified before harvest. Reforestation can be improved by paying greater attention to forest type, soil series, site conditions, and differences in plant communities when selecting harvest method and reforestation techniques.

Keywords: Regeneration (stand), regeneration (natural), regeneration (artificial), clearcutting systems, partial cutting, stand development, Oregon (Siskiyou Mountains), southwestern Oregon.

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